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"To the solid ground
Of Nature trusts the mind that builds for aye."—WORDSWORTH.

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SATURDAY, JULY 5, 1930.

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Librarianship and Scientific Research.

THE growing difficulty of the task of making the ever-expanding mass of published information readily available to workers in every branch of science is a serious problem both in scientific and in industrial research. The value of a uniform international system of classification as the only effective way of dealing with the present enormous output of scientific periodicals was emphasised by most of those who took part in a discussion on the abstracting and classification of scientific literature which followed the annual dinner of the Chemical Engineering Group of the Society of Chemical Industry. Workers on the borderline and in the newer branches of science have suffered most from the absence of a uniform classification, and would gain most immediately by the adoption of the universal decimal classification of the Institut de Bibliographie, of Brussels. This system has already been adopted by a number of reference libraries, including the Science Library, and also in industry, and is used by the Royal Society (for its 'B' papers) and other societies in Great Britain and abroad. So far, the adoption of the international system has not been favoured by the British Bureau of Chemical Abstracts. This is due not to any difficulty in applying the system to the complicated case of chemistry, for the international system allows any chemical compound to be classified, but apparently to doubts as to the value of the system to chemists already familiar with a complicated system of nomenclature.

The adoption of a uniform international system of classification is, however, only a step towards the solution of the problem. A significant feature in the present situation is that in spite of the

excellent abstracting services already available, most, if not all, of the large research associations or departments for scientific or industrial research find it advantageous to issue their own bulletins of abstracts. This is not necessarily a case of overlapping. In the first case, such bulletins will be limited not by sciences but by applications of science, and a particular bulletin of abstracts may cover engineering in several branches, physics, chemistry, and perhaps biology or medicine as they are applied to a particular field of industry. Again, the abstracts in such a bulletin will not be limited to the journals which contain accounts of original work, but will include journals describing applications of such work, etc., and valuable ideas or suggestions are often taken from the technical or trade papers, apart altogether from the commercial information, and other matter that is gathered in this way. Another feature may be the abstracts from patent literature or summaries of work carried out in the department or institution which is not published outside. A bulletin of this kind is essentially a record of current information received in the library, and rarely includes abstracts on the scale of those issued by Science Abstracts or the Bureau of Chemical Abstracts. Its purpose is to stimulate thought and to bring to the notice of those concerned the papers, patents, and other documents, internal or external, which are of immediate interest to them. For this reason, promptitude of publication is an important matter. Such library notes may be in the hands of readers several weeks before the publication even of British Chemical Abstracts, which are noted for their promptness of publication.

One of the points which Major Freeth most stressed in his recent lecture on the influence of technique on research was the isolation of the modern scientific worker. Science lives far too much in water-tight compartments, and frequently men are unaware of first-class work going on within two or three hundred yards of them in another department. This is one result of the extraordinary specialisation of industry and of science, and it persists, if it does not increase, in spite of the widening scope of the abstracting services. The issue of a bulletin of the type just indicated affords a librarian some opportunity of breaking down the isolation of the scientific workers for whom the bulletin is intended. The smaller circle of workers for whom the bulletin is intended permits the issue of a document with rather more personal and vital interest than is possible in the case of one published for scientific workers generally, or even for one class of scientific workers. The shorter abstracts or notes are another advantage. They are much more likely to be read by those to whom it is sent than the lengthier abstracts. Few engaged in scientific or industrial research have not at times been overwhelmed by the mass even of abstracted information which seems to call for attention, and fewer still have diligently and consistently examined the whole. The smaller group of workers also enables the librarian to issue special notices directing the attention of individual workers to papers or publications likely to be of special interest or service to them. In this way a librarian may be able very considerably to assist the director of research who is often responsible for considerably more than the fifteen workers whose investigations he is supposed to be able to direct at maximum efficiency.

The efficient discharge of duties of this type depends very largely upon the personality of the librarian, and a technical librarian is now generally regarded as occupying a key position. His ability to select material for indexing and for issue in bulletin form will be influenced largely by the extent of his practical knowledge of the technical and manufacturing side of the industry. Some such knowledge is fundamental to the specialised work of indexing and classification, and only when the librarian is able to use it in selecting material for his special requirements will industry reap the full value of the International Decimal Classification and improvements in the abstracts issued by the scientific societies.

Under modern conditions a well-equipped and adequately staffed library is an essential feature of any large research department. The increasing volume of scientific literature has indeed enhanced the value of a literature search, and in a recent article* W. A. Hamor and L. W. Bass point to the increasing demand for chemical bibliographers, literature indexers, and the like, as evidence that this is widely recognised. The conditions for literature searches in academic work and in industrial research often differ considerably, and various factors which are emphasised by Hamor and Bass tend to greater thoroughness in the former case, apart from the actual library resources which may be available in the two cases. There is much to be said in support of Dr. S. C. Bradford's suggestion that the preparation of bibliographies or lists of papers dealing with specified subjects should be undertaken by libraries. A literature search is

* "Bibliochresis: The Pilot of Scientific Research", *Science*, 1930. **71**, 375-378.

effected much more thoroughly and rapidly by a trained library staff than by the average research worker. The saving of time for actual research work may be quite considerable enough for the practice of entrusting literature searches to the library staff to become general in industry—perhaps more so if industrial research became organised, as Major Freeth suggests, by divisions of science instead of by divisions of practice.

The efficiency of the technical library for research purposes is, however, determined as much by the personality and enthusiasm of the librarian as by the mechanical perfection of its indexing system. His knowledge of the problems under investigation and their requirements, and his contact with the research staff, are the surest means of promoting contact and the resulting exchange of ideas and technique. The cramping or isolating tendency of the growing mass of recorded scientific information can only be countered by the play of intelligent individuality and enthusiasm.

A Century of Anatomy.

Quain's Elements of Anatomy. Eleventh edition. Editors: Sir Edward Sharpey-Schafer, Dr. Johnson Symington, and Dr. Thomas Hastie Bryce. In 4 volumes. Vol. 4, Part 3: *The Heart.* By Prof. Thomas Walmsley. Pp. vii + 152 + 2 plates. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1929.) 16*s.* net.

THE brief historical introduction which Sir E. Sharpey-Schafer and Prof. Bryce contribute to Prof. Walmsley's monograph on the heart makes brave but gloomy reading.

Jones Quain published his "Anatomy" when he was a lecturer on anatomy in the Medical School, Aldersgate Street, in 1828. With the fifth edition, published twenty years later, the work passed into the hands of his brother, Richard Quain, and William Sharpey, professors respectively of anatomy and general anatomy and physiology in University College, London. Viner Ellis succeeded Richard Quain in the editorship, and was in turn succeeded by Allen Thomson and John Cleland, Sharpey continuing to contribute the general and microscopical anatomy, which had been the most striking change introduced when he first became associated with the work. Although enlarged, it still appeared in two volumes in 1876, when the present publishers issued the eighth edition, which, although contributed largely by Sharpey, Thomson, and Schafer, contained a chapter by Gowers on the brain and spinal cord. Also in two volumes was the ninth edition by Thane, Schafer, and Thomson, dedicated to Sharpey, who at his death had been responsible editor for thirty-five years.

The monographic form was assumed in 1890, when the eight parts of the famous tenth edition began to appear. Since then the only new authors until now have been Profs. Symington and Bryce Godlee assisting in the preparation of an appendix on superficial anatomy in the tenth edition. Sir E. Sharpey-Schafer has been editor for fifty-three years. The War and the death of Prof. Symington interrupted publication of the present (the eleventh) edition, which commenced with Prof. Bryce's volume on embryology in 1908. Monographs on neurology, splanchnology, osteology and arthrology, and myology have appeared, and one on angeology was in preparation by Prof. Bryce. "But the greatly increased cost of printing and engraving has, in the judgment of the publishers, rendered it necessary to postpone indefinitely the publication of this part. As the section upon the Heart . . . was ready for publication, it has been decided to make this the last portion of the edition." Although postponed indefinitely as a part of "Quain's Anatomy", Prof. Bryce's angeology may be published separately, and a volume on the lymphatic system by Prof. Blair will be. As the sole difference in the "cost of printing and engraving" would concern the titles of these works, it seems evident that for the time being publication of "Quain's Anatomy" now ceases in the middle of an edition the first parts of which are already urgently in need of revision.

There is nothing in the English literature of anatomy that will fill the gap. The work began a century ago as a students' handbook, and has developed along lines which, familiar enough on the Continent, are too little valued in England. Rather than a mere inventory of facts, it gave, and might have given increasingly, just that summary and discussion of ascertained knowledge that is necessary to serve as a link between it and the problems of the present. It has served the writers of text-books well on occasion, and a reference to its pages will continue to save many a practitioner from the hasty assertion that "there is nothing in the text-books about it". It is the only modern book on anatomy not written with an eye chiefly on examination papers. These surely are good qualities. In a generation in which medical practitioners look for inspiration to the empiricism of chemistry, therapeutical and metabolic, rather than

to morphology, it is intelligible that an anatomical work more compendious than the standard text-book will not find shelf-room in many studies; but it is to be regretted that the matter should end there.

The distinctive features of the parent work are well illustrated in Prof. Walmsley's contribution. The chapter on the comparative anatomy of the heart is discriminating. The heart is one of the most significant links between vertebrates and invertebrates, and as the heart of the latter has lately received much attention, this part of the subject might have received fuller treatment. The great problems are here. The reviewer agrees with Prof. Walmsley's view that a discussion of the comparative anatomy of the connecting systems of the heart is "perhaps as yet hardly profitable", but not altogether with the statement that the manner in which delay in conduction is produced is not primarily a structural problem. This is, however, not the place to discuss the intricacies of the considerable amount of work which has been done on the development of the conducting mechanisms. Prof. Walmsley recognises that the "whole question of the relation of nerve and muscle is involved" in the interpretation of the facts now known. His presentation of the matter, and indeed the whole section on the structure of the heart, is admirable.

Mathematical Genetics.

Variations- und Erblichkeitsstatistik. Von Prof. Felix Bernstein. (Handbuch der Vererbungswissenschaft, herausgegeben von E. Baur und M. Hartmann, Lieferung 8, Band 1.) Pp. iv + 96. (Berlin: Gebrüder Borntraeger, 1929.) 14·40 gold marks.

AS the sciences develop, they acquire an associated mathematics, and the young science of genetics is evolving a mathematical side at a rate which some of its exponents find disconcerting. Mathematical genetics falls primarily into two sections, which may be called synthetical and analytical. The former deals with the results to be expected on a given hypothesis, but in most cases the populations considered are infinite. The latter is essentially concerned with the theory of sampling, and the inferences which may legitimately be drawn from a given finite sample. Hence their problems are, in general, quite different.

On the synthetical side we meet with dynamical and statical problems. For example, we may wish to know what will be the effect on a population, the variation of which is due to a number of Mendelian genes, of a given type of inbreeding or selection. If generations are separate, we may be faced with anything from one to a series of 22 simultaneous finite difference equations, which may or may not be linear, connecting the values of variables in successive generations. An example of the non-linear type is $\Delta u_n = k f(u_n)$, where f is a known function. In this case n can be expanded as a power series in k. When successive generations overlap, as in man, the difference equations become integral equations. In their solution, functions of a complex variable appear for perhaps the first time in a purely biological problem. Often the dynamical problem is very intractable, but the population considered reaches an equilibrium which can be calculated. Such is the equilibrium between the production of new genes by mutation and their removal by natural selection, which, as Fisher showed, accounts quantitatively for Pearson's results on the inheritance of human stature, if this variation is due to the cumulative action of a large number of genes.

The analytical theory is, of course, very largely the work of Pearson and centres round the properties of the Gaussian error function and related functions. In the case where the population consists of a finite number of classes, his measure of divergence, χ^2, is an intellectual tool of extraordinary simplicity and value, as it enables the geneticist, with great rapidity, to answer two quite different questions. First, can my data, for example, records of a number of families, be regarded as samples of the same population, and therefore legitimately be grouped together? Secondly, with what degree of plausibility can these data be regarded as a sample of a population obeying a given law? A much more difficult type of problem arising from populations of the same type is that of the estimation of a parameter such as the cross-over value. Here there is no royal road to the solution. Bayes' theorem and Fisher's method of maximum likelihood are generally valuable, but cases occur where *ad hoc* methods are preferable.

Finally, we come to populations in which a character exhibits continuous or approximately continuous variation. Here the error function meets us both in the theory of the population itself and in that of samples of it. In spite of the very great labour devoted to this problem by Pearson and his school, we are still far from a really satisfactory mathematical organon, partly owing to

Pearson's reluctance to admit the application of Mendelism to such problems.

In the book before us Prof. Bernstein covers a wider ground than any previous author, and does so in a remarkably short space. After two introductory chapters on probability and statistical theory, he describes the application of statistical methods to data, with special reference to those cases where experiment is impossible, for example, the inheritance of human disease. A good deal, though by no means all, of the ground in this section is covered in Fisher's "Statistical Methods for Research Workers", and the reviewer confesses to a preference for Fisher's methods in many cases. Nearly half the volume is devoted to Mendelian populations, and is the only attempt so far made to unite the more important work on this topic in one book. No student of genetics who is concerned with the wider bearings of his subject and has even a slight knowledge of mathematics can afford to neglect reading it.

There are many defects in this book. For example, it contains no tables, and a regrettable number of errors. Thus, four papers by Robbins are attributed to Pearson. But it is the only book of its kind, and much may be forgiven to a pioneer. We venture to hope that in the near future Prof. Bernstein, who is one of the three or four persons qualified to do so, will give us a full-length book on a subject which is already beginning to have bearings on the theory of evolution, on hygiene, psychology, and politics.

J. B. S. H.

Huygens' Work in Statics and Dynamics.

Œuvres complètes de Christiaan Huygens. Publiées par la Société Hollandaise des Sciences. Tome 16: *Percussion, Question de l'existence et de la perceptibilite du mouvement absolu, Force centrifuge, Travaux divers de statique et de dynamique de 1659 à 1666.* Pp. iv + 500. (La Haye: Martinus Nijhoff, 1929.)

THE appearance of another volume of the superb edition of the complete works of Huygens, in course of publication by the Dutch Society of Sciences, is an event to be welcomed unreservedly. Edited with care and learning, it forms a most valuable and interesting contribution to the history of science in the seventeenth century.

The work here presented falls into three main divisions: (1) impact, (2) centrifugal force, and (3) various researches on problems of statics and dynamics, dating from the period 1659–66. These last have been hitherto unpublished; and none of the work was published in the lifetime of Huygens himself. But each of the first two divisions contains a considerable memoir given to the world in the posthumous edition of 1703. These are entitled "De motu corporum ex percussione" and "De vi centrifuga" respectively.

Huygens observed the first rule for success in life by selecting his father most judiciously. It was under the paternal roof that he came in contact with the learned world, in particular with such men as Descartes, at an early age. But the glamour of Descartes' vivid personality receded as his own critical power developed, and so early as 1652 his researches led him to reject the French author's rules of impact and to supersede them by his own theory. On a visit to London in 1661, Huygens explained his method to some of the leading members of the Royal Society, but though the subject was of recurrent interest at the time, he published nothing beyond a few rules without demonstration in 1669. It appears that the reason for this reticence is to be found in a hope, never abandoned, that he would ultimately succeed in penetrating deeper into the true nature of percussion. It was not due to any dissatisfaction with the memoir prepared in 1656; and, in fact, his literary executors were explicitly instructed to publish this treatise.

It was otherwise with the memoir "De vi centrifuga", which was written in 1659 and published by Huygens' executors in 1703 on their own judgment. These two memoirs are now supplemented by a considerable amount of manuscript material, and linked by a series of notes left in a similar form and dealing with the question of absolute motion. In all this work there is conspicuous a sense of relativity, not of course in its modern meaning, but as a dynamical principle serving the purpose of research. In this respect Huygens made an important advance on the ideas of his predecessors. At first he was mainly concerned with the problem of rotation as a practical inventor, and it was only later that he considered it from a more metaphysical point of view. Adopting the attitude of an observer carried on a rotating disc and supporting a weight by a thread, he assimilated the centrifugal force to the force of gravity. The difficulty of reconciling this view with the Newtonian, which interprets the same phenomena from the point of view of the external, fixed observer, was strongly felt at the time and long after; the two aspects are practically united in d'Alembert's principle.

In any event, the work of Huygens must have exercised a profound influence on the development of dynamical theory, for in his work are to be found clear references to the principles of momentum and of energy. It cannot be an easy task to disentangle the achievement of Newton in this field from the debt which he owed to his contemporaries and predecessors. Perhaps his pre-eminence is to be seen in the generality and sufficiency which he divined in simple principles, and the intellectual confidence which was founded on sure insight, but appeared in a different light to others. The impression recorded by Huygens is instructive and may be quoted :

" Je m'estonne que Mr. Newton sur une hypothese si peu probable et si hardie, se soit donné la peine de bastir tant de Theoremes et comme une theorie entiere des actions des corps celestes. Je dis son hypothese qui est que toutes les petites particules des divers corps s'attirent mutuellement, et cela en raison double reciproque des distances. Il a pu estre conduit a sa theorie des orbites elliptiques par le livre de Borelli du mouvement des satellites de Jupiter, qui . . . n'a pas sceu penetrer les vrais fondements comme Newton qui a eu l'avantage de connoitre la mesure de la force centrifuge par les Theoremes que j'en ay donnèz " (p. 250).

Among the few notes by Huygens on statical problems is one on the breaking of a beam (1662), in which perhaps for the first time a moment is used in its modern sense as the simple product of a force and a distance, a concise notion which only recurs in the work of Varignon in 1687. The dynamical notes refer chiefly to two problems, the tautochronous property of the cycloid and the length of the simple equivalent pendulum for bodies of different shape. On the first of these subjects a complete series of notes makes it possible to trace the idea from the germ to the form finally developed in the " Horologium oscillatorium " in quite unusual detail. Huygens' interest in the second subject was aroused by Mersenne (vir—according to Huygens père—omnigenae sed indigestae eruditionis), who had arrived at the identity of the centres of oscillation and percussion, apparently as the result of experiment. Huygens calculated the position of the centre of oscillation in a number of cases, and reached a certain limited degree of generality by his methods of integration. The term ' moment of inertia ' was only introduced later by Euler (1765), to whom we also owe the convenient symbol Σ (1755).

As the work of Newton is marked by a bold and penetrating generality, so the work of Huygens has its own quality apart from the particular results achieved. This appears in a greater attention to exact definition and an appreciation of the value of precise formulæ, leading to a more concise form of statement than that generally attained to by his predecessors. To quote two of his aphorisms from this volume :

> Nisi principium ponatur nihil demonstrari potest.
> Non est mathematice difficilis materia, sed physice aut hyperphysice (metaphysice).

Hence, as the present editors remark, to Huygens may be traced a distinct influence on the development of mathematical style in the following century. But it was a slow growth, as various passages in the works of Euler may serve to suggest, and it was reserved to the French mathematicians, Lagrange in particular, to set such a standard as can scarcely be surpassed. H. C. P.

Primitive Art.

The Childhood of Art, or The Ascent of Man : a Sketch of the Vicissitudes of his Upward Struggle, based chiefly on the Relics of his Artistic Work in Prehistoric Times. By Herbert Green Spearing. Second and revised edition. Vol. 1. Pp. xxxvi +254+62 plates. Vol. 2. Pp. iv+255-548+56 plates. (London: Ernest Benn, Ltd., 1930.) 42*s*. net.

THE first edition of this book was published so long ago as 1912. It was then rightly acclaimed as a book which no student of early art could afford to be without. It gave a balanced sketch of primitive art as then known with a wealth of illustration. It was up-to-date and truly ' the last word on the subject '.

From 1912 to 1930 is, however, a gap of eighteen years. In the preface to the new edition the author admits that " since 1912 . . . there have been notable archæological discoveries in many parts of the world " ; but he adds that " most of them . . . have only added picturesque details to the connected story ". I fancy by no means everyone will agree with the author in this statement. Surely the new finds at Ur and the Copper Age art of Spain—to give but two examples—have both enriched and complicated the story : they should certainly have been allotted their due space in a revised edition. Even such a discovery as that of the ' sorcerer ' at the Trois Frères cave enlarges our ideas of prehistoric man and is therefore important in a study such as this, which professes to deal

with the ascent of man, traced mainly by studying his artistic achievements. These two volumes are really only a reprint of the original work with the addition of a short preface and the names of a few recent books in the bibliography. It was careless, however, to give Sollas's "Ancient Hunters" as published in 1911 instead of citing the third edition issued in 1924!

It is difficult to understand why the second edition of this work should not have been very largely rewritten. When a second edition of a book is called for soon after its first publication, or when the subject matter is purely an account of observed facts, such as a monograph on some excavation, it is reasonable to reissue what is in reality the same work with the same outlook on the subject. But in the case in question, not only have many recent startling discoveries been made, but many of the problems interesting in 1912 now strike the reader as rather out-of-date. Why quote at length Piette's dogma that sculpture must have preceded line engraving? The fact may have a grain of truth in it (though such Aurignacian line engravings as those found at the abri Labatut have to be taken into account), but Piette, though, in his own time, a pioneer, can no longer be considered as the great authority. He never realised the existence of the Aurignacian culture, and still less did he appreciate that the late Palæolithic art cannot be taken as a single entity, but forms two distinct cycles, one Aurignacian, the other Magdalenian, the evolution of each of which has to be treated separately. What Sumerian authorities will think of the paragraphs dealing with the Sumerians and their art will scarcely be complimentary. Wooley's name does not appear; it is relegated to a few notes in the preface; nor is such a find as the queen's diadem mentioned.

To sum up, the "Childhood of Art" was a good, well-balanced book in 1912. The revised edition is really only a reprint where even the page numbering is the same, and where the only striking differences in the main text are that several plates formerly coloured are now reproduced in black and white; that the table facing page 5 is much abridged; and that the final map is on a far smaller scale than before. Of course there is much that was interesting in 1912 that remains so in 1930, but in the case of a rapidly advancing subject it might have been kinder to have let the author rest on his well-earned laurels without bringing him once again into the arena armed only with the ancient panoply of war.

M. C. B.

Our Bookshelf.

The Flutter of Aeroplane Wings. By R. A. Frazer and W. J. Duncan. (London: H.M. Stationery Office, 1929.) 12*s.* 6*d.* net.

A CRITICAL examination of the causes of a large number of aeroplane accidents, undertaken by the Accidents Investigation Sub-Committee of the Aeronautical Research Committee, has brought out the fact that in many of them a rapid and unusually large movement or flutter of the wings had been apparent. The sub-committee immediately undertook a thorough investigation of the vibration of aeroplane structures, both from the theoretical and experimental point of view, to provide data from which designers could ensure the avoidance of this instability. The work has been undertaken mainly by Messrs. R. A. Frazer and W. J. Duncan at the National Physical Laboratory, and their provisional conclusions and practical recommendations are published in this monograph.

The theoretical part of the volume deals with the equations of motion of the wing-aileron system, with stability criteria, and critical flutter speeds, and with a graphical treatment of binary flutter problems, involving only two degrees of freedom. In the experimental investigation the authors had to develop a special technique for the measurement of the derivatives on flexible wings, due to torsion and flexure of the wing itself, and to aileron movement. The agreement between the observed and calculated critical speeds was sufficiently good to warrant the conclusion that the theory is adequate for the discussion of aeroplane wing flutter; but its real value lies in the methods it suggests for preventing flutter.

The third part of the monograph deals with various recommendations for prevention of each special type of flutter. Cantilever monoplanes, stayed monoplanes and biplanes are separately discussed, and the influences of elastic hysteresis, of friction, and of abnormal wing incidences are thoroughly dealt with.

The monograph has a number of appendices dealing with specialised matters, contains an annotated list of references, and a list of the principal symbols used with their significance. An adequate index for the whole volume is included. It is an excellent record of a very valuable series of investigations.

Ultra-violet Light and Vitamin D in Nutrition. By Katharine Blunt and Ruth Cowan. (The University of Chicago Home Economics Series.) Pp. xiii + 229. (Chicago: University of Chicago Press; London: Cambridge University Press, 1930.) 11*s.* 6*d.* net.

RECENT work on vitamin D and nutrition has been so extensive and so important in practical application that the appearance of an up-to-date monograph on this subject is most welcome. This book provides a convenient account of widely scattered researches, and also includes judicious summaries

of such practical conclusions as are justified in the present state of knowledge.

The first chapter describes some studies on the effect of diet on growth, which are at least encouraging, and confirm the opinion that civilised nations need not deteriorate in physique in spite of urban life. There follows a brief historical chapter, and then an account of the methods of producing and studying experimental rickets in rats in order to detect or estimate vitamin D. This chapter would perhaps be improved by including a fuller account of the radiographic study of rickets in rats, since this method has appreciable advantages over the line test when used for quantitative estimations. There follow chapters on the complex problems of calcium and phosphorus metabolism, on teeth and vitamin D, and on irradiated foods and ergosterol. There is also a section describing some of the physical aspects of ultra-violet radiation, with a well-balanced summary of the advantages and limitations of ultra-violet transmitting glasses intended for the windows of buildings. A further section on the results of actinotherapy is less satisfactory, possibly because of the great difficulty of justly appraising these results at the present time. Each chapter concludes with a bibliography of the more important papers concerned, which adds greatly to its value.

The book can be recommended not only to medical men and others interested in nutrition, but also to research workers who may need a summary of branches of work allied to their own special subjects.

R. B. B.

(1) *Air Defence*. By Major-Gen. E. B. Ashmore. Pp. viii + 179. (London, New York and Toronto: Longmans, Green and Co., Ltd., 1929.) 8*s*. 6*d*. net.

(2) *La folie et la guerre de 1914–1918*. Par A. Rodiet et Prof. A. Fribourg-Blanc. Pp. iii + 194 + 10 planches. (Paris: Félix Alcan, 1930.) 30 francs.

THESE two books may be included in one notice, for they both deal with the War, though from entirely different points of view. General Ashmore, who was placed in command of the London Air Defences in 1917, succeeded in organising a very telling defence, following upon the previous feeble results recorded against German raids, particularly as regards aeroplanes. He develops his subject herein as lucidly as he developed the defences, and higher praise it is impossible to bestow. His concluding remark is worthy of note: "If we maintain an efficient air defence, we may never be attacked".

The other book details the effect of the War in producing or intensifying mental alienation in French subjects, and deals with 220 cases out of a total approximating 25,000. Investigation suggested that the syndrome known as shell-shock was not to be regarded as a special form of mental disease, but merely as the determining factor in a general condition of mental obliquity. Further, it is remarked that psychoses associated with, or succeeding, infectious diseases would doubtless have been very numerous, had it not been for the prophylactic measures taken at the commencement of the War. There are intensely interesting notes upon malingering, and altogether this is a very valuable compilation.

P. L. M.

Diet and Efficiency: a Five-year Controlled Experiment on Man. By Harold H. G. Holck. (The University of Chicago Monographs in Medicine.) Pp. ix + 72. (Chicago: University of Chicago Press; London: Cambridge University Press, 1929.) 4*s*. 6*d*. net.

THE purpose of this experiment carried out on a single individual was to determine the effect upon mental and physical processes of a fairly strict adherence to the principles of nutrition laid down by Fletcher. These principles may be stated thus: (1) Eat only when actually hungry; (2) stop when satisfied; (3) chew the food especially well; (4) if available try to secure any food for which there seems to be a craving and omit those to which there may be antagonism. Of the five years of the experiment, only about 18 months were taken up by the experiment proper, the remainder being pre- and post-periods. Very full records were kept throughout.

The results may be stated quite briefly: the eating time per 1000 cal. was doubled and the food intake was at a minimum, although its percentage composition of protein, fat, and carbohydrate was almost unchanged, as compared with the control periods. Muscular endurance, typewriting accuracy, and basal metabolism were reduced, but there was no change in blood-pressure, pulse-rate, temperature, sleeping time, mental multiplication, and typewriting speed: efficiency in solving chess problems was improved. The body weight was reduced to the accepted standard for the subject's height and age. The general conclusion appears to be that reduction in food intake in a somewhat overweight subject does not always lead to improvement in mental and physical well-being, and that the minimum intake compatible with maintenance of weight at an accepted 'standard' level may not be the optimum in all cases.

Alpine Flowers: the Most Common Alpine Plants of Switzerland, Austria, and Bavaria. By Dr. Gustav Hegi. Authorised translation by Winifred M. Deans. Pp. xiii + 74 + 38 plates. (London, Glasgow and Bombay: Blackie and Son, Ltd., 1930.) 7*s*. 6*d*. net.

MISS DEANS has prepared an excellent translation of Dr. Hegi's handy little book, "Alpenflora", which should be very useful to visitors to the Alps who may wish to identify the flowers they come across in their rambles on the mountains. All the plants described are illustrated, and the coloured plates are, on the whole, quite good, and allow the plants to be determined with ease. The botanist may be somewhat disappointed, since so many of the plants he would come across are not referred to in the book, but for him the larger works on the Alpine flora are available. The general flower-loving public should welcome the book.

Letters to the Editor.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, nor to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.]*

Space and Matter.

REFERRING to NATURE of June 14 and to the interesting résumé on page 897 of Prof. Einstein's Nottingham lecture, I note that he virtually agrees with me in claiming matter as passive and space as active. Matter is that which is acted upon; space is that which acts. Matter is inert; space is energetic. Matter *does* nothing, though it serves to display the energy of which space is full: it merely sails placidly along the path of least resistance, like a straw in a stream or a leaf in the wind.

It used to be thought that potential or static energy existed in the ether, while locomotive energy was possessed by matter; but we now know that momentum is electromagnetic, and accordingly exists in the space around the unit of matter which displays it. So, strictly speaking, all energy belongs to space: matter only affords a means of detecting and using it.

There is no objection to an inert thing being able to receive and transmit energy; and yet when we say that matter is a form of energy, equal to mc^2, it is clear from the occurrence of c that space must really be responsible for the energy. So also for the increase of energy due to motion, which is responsible for the kind of relative kinetic energy familiar to engineers; c is involved in that too. For $\frac{1}{2}mv^2 = c^2dm$. As for the irregular or statistical energy that we call heat and usually consider material, the heat motion of particles is partly visible in the Brownian movement, which as temperature rises must grow in intensity. Whatever is true about the locomotion of particles is true also of this irregular motion.

We know that the mass of an electron is accounted for by the energy of its electrostatic field. So matter, strictly speaking, has no active properties at all. When we say that matter is a form of energy, we mean that its existence is the sign or symbol of certain kinds of energy in space, and affords a possible means of getting at it. (It would be pedantic and inconvenient to be perpetually remembering this, so we may still attribute momentum and kinetic energy and heat energy to matter.)

This applies to all matter. There is no discrimination between the so-called animated variety and any other. Hence the task of the biologist or the behaviourist to explain vital activity in terms of matter must be futile. Every part of every body must be controlled, guided, activated, by something in space. When an organism interferes with, or in, the course of Nature, it does so because it is actuated by something outside itself; something familiar in its effects, and usually called Life, but not yet discovered or formulated in proper terms.

Although matter has no energy and never does anything, yet it is to us the conspicuous thing, because our nerves, which are themselves material, respond to the perturbations of space; thereby stimulating our sense-organs, and giving us information about those perturbations. Matter is one of the perturbations, but it is entirely inert. Space is the primary and active thing.

Space with physical properties is usually called ether; but what those properties in themselves are, is the problem before us—a problem which must have deep-seated philosophical consequences. OLIVER LODGE.

Normanton House, Lake, Salisbury, June 20.

Absorption of Sound at Oblique Incidence.

IN the U.S. Bureau of Standards' *Journal of Research* for February 1930, pp. 289-296, there appears a description of apparatus employed by P. R. Heyl, V. L. Chrisler, and W. F. Snyder, for the investigation of the absorption of sound at oblique incidence. A plate of the material to be tested was placed at a flat elbow joining two cylindrical pipes in the way shown diagrammatically in the accompanying sketch (Fig. 1). The results obtained were compared with certain calculations made by me relating to the reflection of plane waves of sound from a flat surface.

The theory underlying the method appears to be that plane waves travelling down the pipe A will be reflected from the plate of material under test and will pass into B in accordance with the laws of rectilinear propagation as commonly employed in optics when the dimensions of the reflecting surface are large compared with the wave-length. In the experiments at the Bureau of Standards, however, the diameter of the pipes which convey the sound to and from the test plate was only a fraction of the wave-

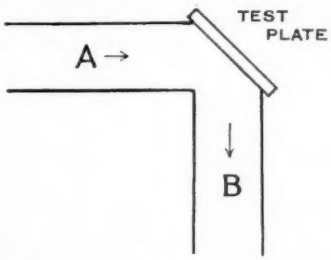


FIG. 1.

length of the sound employed, and an assumption of rectilinear propagation at the elbow seems scarcely to be justified. Part of the energy of a plane wave travelling along A will pass into B by diffraction, and also any sound reflected from the test plate will spread partly into A and partly into B. For these reasons I am inclined to think that very little value can be attached to the coefficients of absorption at oblique incidence which are given in the paper referred to. At any rate, they are certainly not the coefficients for plane waves at oblique incidence.

One of the substances tested at the Bureau of Standards was 'akoustolith', an acoustic tile similar to certain acoustic plasters concerning which I have made theoretical deductions leading to the conclusion that the coefficient of absorption for plane waves at oblique incidence would, except near grazing incidence, be greater than at normal incidence (*Proc. Roy. Soc.*, **A, 115,** pp. 417-419; 1927). Heyl, Chrisler, and Snyder found with their apparatus that the absorption of akoustolith (at 512 and 1024 cycle/sec.) was less at 45° and 60° than at normal incidence, and less at 45° than at 60°. To explain the discrepancy between their observations and the theoretical conclusions, they invoke the aid of "a thin layer of air close to the absorbing surface" where the "differential equation for sound motion in air is not valid" (loc. cit., p. 290). In this layer they imagine there is a rotational motion of the air particles, and conclude that "it is unsafe to apply to such a region mathematical analysis involving the assumption of the existence of a velocity potential. Theoretical conclusions based on such reasoning are invalid" (p. 295). There appears to be no evidence that this layer exists (or that, even if it exists, it exerts any perceptible effect on sound absorption) apart from the discrepancy referred to

above, and this could equally well be explained by the falsity of the assumption that the observed coefficients are those for plane waves at oblique incidence.

In the theory which I have attempted to develop of the absorption of sound at oblique incidence by substances such as akoustolith, it is assumed that air is forced into and out of the pores by the pressure variations at the reflecting surface, and that this in-and-out motion is accompanied by the degradation of sound energy into heat. I believe that this degradation takes place inside the pores and is due to the working of viscous forces, but it may be remarked that this view is not shared by Heyl, Chrisler, and Snyder, who think that there may be degradation due to viscous forces just outside the reflecting surface. Thus they say (p. 290) that "even with glass which has no sensible pores, there is an appreciable amount of absorption of sound which must arise from friction of some kind, probably of a sliding nature". It would be interesting to know the reason for supposing that the absorption (that is, loss at reflection) must necessarily be due to friction. The fact is that there is a loss of energy at reflection amounting to some 2 or 3 per cent, and I suggest that this could be accounted for by the transmission of sound into and through the glass test plate.

In the theory of sound absorption at oblique incidence it is assumed that the mass-flow of air into the pores (dm/dt) per unit area of reflecting surface is connected with the pressure variation (p) at the reflecting surface by the equation $dm/dt = \Omega p$, where Ω is a complex quantity (the acoustical admittance per unit area) which is constant for a given surface and wave-length of sound. The incident and reflected waves were, for convenience, represented by velocity potentials, but the motions inside the pores were not taken into consideration. The quantity Ω can be measured with the usual type of stationary wave apparatus, and the absorption at any angle of incidence could then be calculated by means of a formula given in the paper quoted above. The mechanism by which the loss of energy from the incident wave occurs (apart from the fact that it is associated with the motion of the air into and out of the pores) need not be known.

The late Lord Rayleigh, in his paper on "The Resonant Reflexion of Sound from a Perforated Wall" ("Sci. Papers", **6**, p. 662), used potentials to represent the incident and reflected waves and also the wave transmitted into the pores, this last potential being chosen so as to represent the dissipation of energy by viscosity in the pores. I see no objection to such a treatment, and there seems to be no reason for doubting the general truth of the formulæ which he obtained for the reflection of sound waves at oblique incidence.

In their "Discussion of Results", Heyl, Chrisler, and Snyder advance theoretical reasons (p. 294) for supposing that the coefficient of absorption will "diminish steadily with increasing obliquity of incidence". They begin with a statement that "a sound wave is not a convection current". No one is likely to quarrel with this premise, but I have been quite unable to follow their subsequent line of thought. It is considered that the amount of absorption is closely connected with the 'average pressure' over the reflecting surface. Except for the second order 'radiation pressure', I should have thought that the average pressure over a reflecting surface would be atmospheric pressure no matter what might be the angle of incidence. Certainly this would be so in the case of plane progressive waves reflected from a flat surface.

The interest attaching to the determination of the coefficient of absorption for plane waves at oblique incidence is partly due to the fact that if the coefficient for some material were known for all angles of incidence, an experimental test could be made of the theory of reverberation. In this theory, which was developed by W. C. Sabine to account for his experimentally established laws of reverberation, rectilinear propagation of sound is assumed, and, if the theory is true, it is possible to calculate the coefficient of sound absorption, as it would be measured in a reverberation experiment, from the values of the coefficient at oblique incidence. The method of calculation is given in *Phil. Mag.*, **5**, pp. 489-497; 1928. The theory that absorption increases with angle of incidence does at least offer an explanation, on the basis of reverberation theory, of why the reverberation coefficients of acoustic plasters, etc., are found to be greater than their coefficients at normal incidence. I cannot see any reason why, if, as Heyl, Chrisler, and Snyder suppose, the absorption decreases with angle of incidence, the absorption in reverberation should be greater than when the waves are incident normally. I should have expected exactly the opposite.

One of the conclusions reached at the Bureau of Standards is that "in the practical measurement of absorption coefficients the reverberation method should be the only one trusted for absolute values of the coefficient". It would be of interest to know what is meant by the 'absolute' value of the coefficient and how it differs from any other value. The method adopted must surely depend on the quantity it is desired to measure. Coefficients at normal incidence can best be determined with stationary wave apparatus, while reverberation coefficients are at present most suitably found by reverberation experiments. It is, however, at least possible, and even probable, that reverberation coefficients could be calculated from observations made with stationary wave apparatus.

E. T. PARIS.

Shortlands, Kent,
May 20.

Origin of Asymmetry in Gastropods.

IN his review of Dr. de Beer's "Embryology and Evolution" (June 14, p. 883), Prof. MacBride appeals to readers of NATURE to decide between two theories of the origin of asymmetry in Gastropods. He supports the opinion that the weight of the shell stretched one side of the animal and crushed the other, thus initiating an inequality of growth. On the alternative view "a sudden and miraculous mutation" twisted the visceral hump and shell through 180°.

Now the first theory postulates the transmission to the offspring of the effects of injury, to wit, stretching and crushing. Whatever may be the case with other acquired characters, attempts to prove the inheritance of the effects of mechanical injury have been conspicuously unsuccessful. On the other hand, "miraculous mutations" resulting in asymmetry of symmetrical animals have been reported. Thus Bridges and Morgan [1] describe a mutant form of *Drosophila melanogaster* in which the abdomen is rotated to the left through 60° to 90°. This type has a poor viability, and cannot mate, hence the mutation is disadvantageous to *Drosophila*. If it were advantageous it would be perpetuated by natural selection.

While I see no reason to adopt either of these theories, which are not mutually exclusive, as to an event which took place in pre-Cambrian times, I find

the second more attractive because, unlike the first, it is based on analogy with facts which have actually been observed.

J. B. S. HALDANE.

John Innes Horticultural Institution,
Merton Park, London, S.W.19,
June 17.

[1] Bridges and Morgan: *Carnegie Inst. Pub.* 327.

IN the above letter, Mr. Haldane misinterprets the theory of the origin of Gastropoda as a consequence of the sagging of the visceral hump to one side. The sagging of the visceral hump no more 'injured' the ancestral mollusc than does the weight of her protuberant abdomen a pregnant woman. It continually stimulated the skin of one side by stretching it, and what was transmitted to posterity was not the passive stretching but the altered *habit of growth* called forth in response to it. That such altered habits of growth do become hereditary has been proved by every relevant experiment on the subject. As I have said elsewhere, Przibram enumerated at least six examples of this. I have just returned from a northern university where pioneering genetical research is going on. I think it probable that in the near future Przibram's six examples will become at least ten.

Mr. Haldane instances a *Drosophila* with distorted abdomen as giving an example of the sudden miraculous mutation which De Beer postulated as the origin of the Gastropoda. He admits that this individual was so enfeebled that it would not mate, much less give rise to offspring. He overlooks the fact that the want of viability of the mutants of *Drosophila* is in direct proportion to their divergence from the type; and the idea that an enfeebled mutant would be preserved by 'natural selection' when all its normal bilaterally symmetrical fellows perished is one that cannot be entertained. No competent systematist, palæontologist, or embryologist would agree with Mr. Haldane, and it is these people who have the final word on the causes and course of evolution.

E. W. MACBRIDE.

Royal College of Science,
South Kensington, S.W.7,
June 23.

The Position of Fundamental Research.

IN the interesting leading article in NATURE of May 31, a lament is sounded that pure research of the kind fostered in colleges and universities is no longer able to attract the best of the younger scientific students. The cause is attributed to the relatively poor salaries which colleges can offer; and this opinion is substantiated by comparison between the financial rewards of commerce and industry on one hand, and of the teaching and research profession on the other.

Although lack of money may be a powerful contributory reason, it would seem that the real cause of the shortage lies deeper. Surely pure research is done best by persons who are inspired in their work, and supported best by institutions to whom their work is useful.

The universities fostered research because teachers could not, in general, remain in the forefront of their respective fields unless they were creating as well as retailing knowledge. It was recognised that research was necessary to inspire teaching; and later the interesting belief became common that teaching, with its continual summarising of existing knowledge, its regular routine, and the stimulus of irksome duties and of question and of answer, was equally necessary to fertilise research. That was when the preponderance of scientific knowledge was situated within the university campus.

At the present time much of scientific learning is housed within the walls of industry, and it is to industry that even your pure scientist looks for the greatest inspiration. Industry in America has known for years that works laboratories stocked with technicians, inventors, and trouble tracers soon become sterile unless pure research, with its right to publish and its consequent prestige to the individual, is carefully fostered. This does not mean necessarily that a few privileged persons are permitted to pioneer scientifically in a building where others are kept strictly to the kind of work bearing immediate profit. It means often that those who have the mental equipment use part of their time on industrial problems, part in pursuit of their scientific hobby—pure research. One has only to cite Langmuir's work on adsorption, Sheppard's discoveries in photographic sensitivity, or the scientific publications of the Bell Telephone Laboratories, to see how amazingly industry has stimulated scientific minds in the pursuit of knowledge for its own sake.

The old academic feeling that there was something vaguely discreditable in a discovery which could be put to practical use is passing. Those who love knowledge for its own sake now often have the double satisfaction of securing an advance of understanding, and at the same time seeing this advance aiding the manufacture of some product in enormous quantities.

The tragedy, one feels, is not that the colleges can no longer attract young men for research, but that they cannot provide the whole environment of research, leisure, and remuneration which is necessary to secure the best men to train those other keen young scientists who will later find their opportunity in the industrial research laboratories.

K. HICKMAN.

Eastman Kodak Company,
Research Laboratories,
Rochester, N.Y.

Triatomic Hydrogen.

IN recent years various observers have investigated the formation of active hydrogen in discharge tubes at pressures ranging from two centimetres to atmospheric. The evidence has been both positive and negative.

In the formation of atomic hydrogen by R. W. Wood's method, it is considered that the water vapour poisons the glass walls and prevents the reversion to molecular hydrogen. Lewis (*Jour. Am. Chem. Soc.*, **51**, 654; 1929), in a study of the influence of surface upon the after glow in nitrogen, found that water vapour or paraffin poisoned the walls of the glass bulb to such an extent that the life period of the glow was doubled or tripled.

A study has been made of the influence of surface upon the formation of triatomic hydrogen based upon Wood's theory. We have repeated the work of Urey and Smallwood (*Jour. Am. Chem. Soc.*, **50**, 620; 1928) dealing with corona and vacuum tube discharges. We find that their results are correct under their experimental conditions. No appreciable activation of hydrogen is observed. However, when we introduced a trace of oxygen before the gas mixture reached the discharge tube, the results were positive as shown by the lead sulphide formed on the lead acetate paper.

To test Wood's theory still further, we poisoned the walls of the discharge tube with stearic acid and omitted the oxygen from the stream of pure hydrogen. The results were again positive, showing that hydrogen is activated in discharge tubes above 2 cm. pressure. During the latter part of this work, fresh plastic

sulphur was used in place of flowers of sulphur. The flowers of sulphur were treated to remove volatile sulphides. A large number of blanks were run wherever there was any doubt existing about results being influenced by sulphur blown back into the discharge tube. We found tubes easily contaminated until we used plastic sulphur.

During the course of this work a paper by Wartenberg and Shultz was published (*Zeit. Physik. Chem.*, **6**, 261; 1930) showing that orthophosphoric or metaphosphoric acid may be used successfully to poison the walls of a Wood's discharge tube in the production of atomic hydrogen.

Our experimental evidence further supports R. W. Wood's theory, and offers an explanation of the discrepancies existing regarding the production of triatomic hydrogen in discharge tubes.

We can duplicate the work of Urey and Smallwood if we remove the oxygen from the gas stream. If we introduce a trace of oxygen we check the results of Wendt and Landauer (*Jour. Am. Chem. Soc.*, **42**, 930; 1920. *Ibid.*, **44**, 510; 1922).

We wish to express our appreciation to the Canadian National Research Council for aid during the course of this work.

J. L. BINDER.
E. A. FILBY.
A. C. GRUBB.

University of Saskatchewan.

Pleochroism and Crystal Structure.

IN a very important paper (*Phil. Mag.*, vol. 33, p. 521; 1917), Silberstein developed a theory of molecular refractivity based on the idea that the electric doublets induced by the field of the light wave in the atoms composing the molecule influence each other, the result of such atomic interaction largely depending on their relative distances and the geometric form of the molecule. One important consequence of Silberstein's theory, namely, that gaseous molecules should in general be optically anisotropic, is supported by observation, and has been worked out in detail by Ramanathan, Havelock, and others; it also forms the basis of W. L. Bragg's well-known and successful attempt to compute theoretically the birefringence of the solid carbonates and nitrates from their known crystal structure.

In the present note we desire to direct attention to another important consequence of Silberstein's theory, namely, that atomic interaction induces pleochroism in ions or molecules: such pleochroism would become accessible to observation when they are regularly oriented as in a crystal. In a recent paper (*Ind. Jour. Phys.*, vol. 4, p. 1; 1929), Sir C. V. Raman and S. Bhagavantam have indeed suggested that the colour and pleochroism of solid organic compounds arise in this way. We have made some observations on the absorption of *polarised ultra-violet light* in crystals of sodium and potassium nitrates which appear to be very significant in this connexion.

It is known from the X-ray evidence that the NO_3 ions form a plane structure normal to the trigonal axis in sodium nitrate and to the pseudo-hexagonal axis ('*c*' axis) in potassium nitrate. We have found that the selective absorption at about 3000 A. which appears in aqueous solutions of the nitrates manifests itself in the solid crystals only when the vibrations are in the plane of the NO_3 ions; vibrations of this frequency perpendicular to the plane of the NO_3 ions are freely transmitted by the crystals. Further, beyond about 2600 A. begins another region of strong absorption in the crystals which is also polarised in the same direction as the 3000 A. band. It is also found that while the refractive index of the ordinary ray shows a rapid increase even in the visible region with diminishing wave-length, the corresponding increase in that of the extraordinary ray is much slower. These observations taken together with W. L. Bragg's work on the birefringence of the nitrates appear to indicate that the basic ideas of Silberstein's theory are substantially valid.

K. S. KRISHNAN.
A. C. DASGUPTA.

Physics Laboratory,
Dacca University,
Dacca, May 19.

Sense of Smell of Longicorn Beetles.

IN the notice of Ivar Trägårdh's paper on the pine-sawyer pest in Sweden, which appeared in NATURE of April 5, page 546, doubt is expressed that longicorn beetles are attracted by means of their sense of smell "to trees in the condition they require for oviposition". The writer of the notice cites an opinion held some twenty years ago that the Indian sal heartwood borer, *Hoplocerambyx spinicornis*, discovers newly felled trees by an unerring 'instinct' ("Indian Forest Insects", p. 323).

Recent field-work on the biology of *Hoplocerambyx* supports the contention of Trägårdh, for the beetles (of both sexes) react immediately to the smell of a newly felled *Shorea robusta*, and in particular to that of the sap freshly liberated by the act of felling. If beetles happen to be near at hand, they discover the tree in the course of a few minutes. By cutting isolated sal trees in open country, it is possible to attract beetles in less than an hour from forest at a distance of at least half a mile. I have observed that the beetles approach upwind, flying low, and in a remarkably straight course towards their objective; with an appreciable breeze no beetles appeared from the forest to the windward. Arrived at the tree they drink the sap. As this species is on the wing during the monsoon season, they are not attracted to the tree for the sake of water only.

In the course of a day or two the attraction of the felled tree diminishes considerably and the beetles disperse; but by logging the tree or by stripping off the bark, or by otherwise exposing fresher sap, the attractiveness of the tree can be renewed for a further short period, and new beetles appear.

This principle has been used in the control operations against the sal heartwood borer during the recent serious epidemic in Central India; by means of trap-trees felled at appropriate periods and inspected systematically, millions of beetles have been collected and destroyed.

C. F. C. BEESON.

Forest Research Institute,
Dehra Dun, India, May 20.

Kekule and Kolbe.

I WRITE Kekule without an accent, as he was a descendant of old Bohemian nobles, the Kekule de Stradonice, whose ancestors, being Bohemian brothers, had to emigrate after the battle of the White Mountain (1620); it is he whom we thank for the reform of organic chemistry. As a man of Slavonic origin Kekule was a 'romanticist' and arrived at his doctrine of the chemical structure more by genial intuition than by experimental investigation (see Brauner; "Collection" II., 225). On the other hand, I agree with my old friend, Prof. Armstrong, who said in his excellent review (NATURE, May 31, 1930, pp. 807-810) that the rôle played by Kolbe in our science is often

insufficiently appreciated. This is probably due to the circumstance that not all teachers of chemistry stick to the principle that special lectures on the evolution of chemical theories ought to be given to advanced students, as I did for many years. Kolbe was the type of a 'classicist' of German origin. His work was done under the influence of his great teacher, Bunsen, another 'classicist'. I wish only to direct attention to the constitution of carbonic acid, $C_2O_2{}^{OHO}_{OHO}$, and its derivatives, which, though written in Gmelin's equivalents, was, according to my modest opinion, the first correct structural formula and in which the carbon atom C_2, translated into our modern views, appears as *tetravalent*. For the same reason it follows from his formula of sulphuric acid, $S_2O_4{}^{OHO}_{OHO}$, that it is a structural formula containing *hexavalent* sulphur. Both geniuses retain their value.

BOHUSLAV BRAUNER.

Bohemian Academy, Prague,
June 8.

Flint Implements of Lower Palæolithic Age from Yorkshire.

IN NATURE of June 7 appears a letter from Mr. J. P. T. Burchell stating that Mr. Dewey and myself have made an official examination for the Geological Survey of the sites in Yorkshire from which Mr. Burchell has obtained implements. His letter gives the impression that we are substantially in agreement with him on the claims made in NATURE of Feb. 15, where the implements are said to be from "the base of the Uppermost Boulder Clay of the area"; whereas Mr. Burchell is fully aware that both Mr. Dewey and I deny that the deposit is a Boulder Clay.

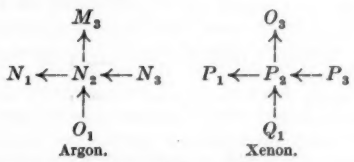
As several Yorkshire geologists have expressed their surprise at the views which Mr. Burchell's letter has led them to attribute to me, I wish to state that in my opinion the deposit containing worked flints, though it may belong to the latest stage of the Pleistocene, is of much later date than the latest Boulder Clay. Reasons for this opinion will be given in the detailed report shortly to be issued. I am content, as a geologist, to leave the cultural stage of the flints to be settled by the archæologists; if there should be general agreement that they are Palæolithic I can accept the overlying deposit as latest Pleistocene; but I am equally ready to accept it as Recent or Holocene, if the flints are Neolithic or later. I also consider that the flake mentioned in the last paragraph of Mr. Burchell's letter as having been found at Burstwick in my company may "from its stratigraphical position" be much "later in date than the Early Mousterian period".

C. N. BROMEHEAD.

Geological Survey Office,
York, June 19.

Spectrum of Inert Gases in their Second Stage of Ionisation.

ARGON, krypton, and xenon when they are excited to their second stage of ionisation give rise to spectra which should theoretically come under quintet and triplet systems. The position of different transitions can without difficulty be predicted with the help of the 'irregular doublet' law and the 'horizontal comparison' law (*Ind. J. Phy.*, vol. 3, part 1; 1928). Thus, with the knowledge of the nature and the position of the spectra we could identify certain lines and finally classified lines arising from the transitions below:



The following chart shows the details:

	Argon.	Xenon.	
$X_2{}^5D_4 \leftarrow Y_2{}^5P_3$	29964·5	25479·8	where X, Y, Z
$Y_1{}^5S_2 \leftarrow Y_2{}^5P_3$	30424·2	26437·5	correspond to
$Y_2{}^5P_3 \leftarrow Z_1{}^5S_2$	33058·3	34393·1	M, N, O for
$Y_2{}^5P_3 \leftarrow Y_2{}^5D_4$	41248·4	36788·0	argon, and
diff. $^5P_2 - {}^5P_1$	86	291	O, P, Q for
" $^5P_3 - {}^5P_2$	148	415	xenon.

For krypton, Prof. Acharya identified the line 30800·0 as $^5S_2 - {}^5P_3$ due to the transition $(O_1 \leftarrow O_2)$, (NATURE, Feb. 16, 1929); but from the consideration of the differences $P_2 - P_1$ and $P_3 - P_2$, as well as from the intensity, we see that the probability of the line 30858·8 is greater for the transition than that previously identified by Mr. Acharya. The differences $P_2 - P_1$ and $P_3 - P_2$ are 162 and 273 respectively.

S. C. DEB.
A. K. DUTT.

Physical Laboratory,
University of Allahabad,
May 2.

Band Systems Associated with Selenium.

A LARGE number of heads in the band spectrum attributed to selenium have been carefully measured by Messerschmitt.[1] A number of these can be identified with heads in the absorption and fluorescence spectra analysed by Rosen.[2] These form a system which I have called the α system. Nearly all the remaining heads fall into two other singlet systems, the β system, consisting of a number of very diffuse bands in the blue, and the γ system, consisting of a large number of bands in the green and yellow. The heads of the three systems can be represented by the following formulæ:

α system—
$$\nu = 27371 + [254{\cdot}7(\nu' + \tfrac{1}{2}) - 2{\cdot}42(\nu' + \tfrac{1}{2})^2] - [387{\cdot}8(\nu'' + \tfrac{1}{2}) - 0{\cdot}63(\nu'' + \tfrac{1}{2})^2]$$

β system—
$$\nu = 21945 + [431{\cdot}1(\nu' + \tfrac{1}{2}) - 0{\cdot}83(\nu' + \tfrac{1}{2})^2] - [373{\cdot}5(\nu'' + \tfrac{1}{2}) + 0{\cdot}66(\nu'' + \tfrac{1}{2})^2]$$

γ system—
$$\nu = 18432 + [336{\cdot}3(\nu' + \tfrac{1}{2}) - 0{\cdot}19(\nu' + \tfrac{1}{2})^2] - [386{\cdot}5(\nu'' + \tfrac{1}{2}) - 0{\cdot}59(\nu'' + \tfrac{1}{2})^2]$$

It is probable that the α and γ systems have the same final level. It does not seem possible to come to any definite conclusion whether this is also the final level of the β system, as the measurements are probably not very accurate, owing to the extremely diffuse nature of the bands.

Work on the fine structure which is at present in progress indicates that the α system is due to a $^3\Sigma \longrightarrow {}^3\Sigma$ transition.

It is hoped to publish full details in the autumn.

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[1] Messerschmitt: *Zs. wiss. Photographie*, vol. 5, pp. 249-278; 1907.
[2] Rosen: *Zeits. f. Phy.*, vol. 43, p. 95; 1927.

History of Research in Cosmic Rays.*

By Dr. ROBERT A. MILLIKAN,
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IN general, discussions of priority, save perhaps in the hands of the historian of science, seem to me to serve no useful purpose, since they represent, in the main, the *ex parte* statements of persons who are not in position to form scientific, objective judgments. The task properly belongs to posterity. The real scientific worker, whose primary interest is in the progress of science, can scarcely take the time to enter into these discussions even when he himself is badly misrepresented for the time being. In any case he may usually count on the facts ultimately coming to light.

In order, however, that the uninformed public may not be too long misled by the quite unusual number of incorrect statements and implications that have been made in recent discussions in both the popular and the scientific press upon the subject of ' cosmic rays ' (and I have never, directly or indirectly, by implication or suggestion used or authorised any other name, and I know of no other designation which is as appropriate), I am now issuing, at the urgent request, especially of some of my German friends, this single statement, partly to direct attention to some facts quite generally overlooked, and partly for the sake of requesting anyone who is interested in forming an unbiased judgment to read for himself first the articles that I have written, either alone or in collaboration, rather than to depend for his impressions upon reviews or newspaper headlines of any sort. For these latter, whether unduly favourable or unfavourable (and both sorts have appeared), I obviously have no sort of responsibility and I cannot possibly find the time to correct all the erroneous statements that appear.

My own articles, on the other hand, and those published in collaboration with others (and the chief ones here involved and for which I have any responsibility are those represented by the subjoined references (1-9), have been written with the most careful effort to give the correct historical perspective to the field as it existed at the time our own results reported in these articles were obtained, in so far as the brevity necessitated by the nature of the articles permitted, and my attention has not yet been directed to any erroneous statement, implication, or oversight in our presentation of the essential history of the subject. Indeed, before these particular articles were submitted for publication, they were read and approved (as my more important papers usually have been) by three of the best informed physicists of my acquaintance, one of them an outstanding European, for the very purpose of getting the most trustworthy possible judgments as to essential correctness of statement and implication.

In spite of these precautions, misunderstandings seem to have arisen and a spirit of unfriendliness and suspicion of motives to have been engendered which I can account for only upon the assumption that it is another unfortunate aftermath of the War. This spirit, illustrated by the title " Zu Abwehr . . ." of an article found on p. 705 of *Physikalische Zeitschrift*, **19**, has led the authors to make altogether unjustified charges, to which my German friends have urged me to make some reply so as to prevent, in so far as it is still possible to do so, the further spread of misunderstandings. I can do so in a brief article only by presenting again the most essential elements in this history and by referring for more complete bibliographies to such excellent treatments as are found, for example, in Meyer and Schweidler's " Radioactivität " (Teubner, 1927), Chapter vii. pp. 546-624. These authors show an admirable objectiveness in their presentation, and give quite as complete a bibliography as could be expected, though the present article will perhaps add a few more to their list of references useful for succeeding editors.

The most significant contributions of my associates and myself to this whole field of cosmic rays have consisted (1) in obtaining experimental ionisation-depth curves that show that the cosmic rays have the structure of spectral bands of such frequencies or penetrating powers as to be interpretable, if Einstein's equation and Aston's curve are correct, not at all in terms of radioactive or disintegrating atomic processes, nor yet in terms of many-million-volt electronic impacts (up to 400,000,000) as we had earlier thought likely, but rather, as we interpret the evidence, in terms of definite atom-building processes ; (2) in obtaining *experimental evidence* as to where these atom-building processes seem to be going on.

I have never even attempted in preceding articles to trace the origin and history of the *speculative* idea of atom-building in cosmic processes—a difficult matter, since it has been well nigh universal property for more than twenty years, but if it will assist the historian of this field I shall be glad to recount here the history of my own knowledge of the subject.

So early as 1904, when I was engaged in a study of the ratio of the radioactivity and uranium content of certain ores,[10] Prof. F. R. Moulton came to me at the University of Chicago with the statement that, if the sun had been originally pure uranium, it would not have been able to pour out so much energy as was demanded by what he regarded as trustworthy estimates of its minimum lifetime, and that therefore cosmogony demanded some thus far unknown source of stellar energy.

Now, this source had, in fact, already been found, though I myself was not at that time wise enough to appreciate it, for the interconvertibility of mass and energy had, in fact, been experimentally demonstrated for special cases by the Kaufmann experiments of 1901, and the facts of radiation

* This article is one of which I sent a German translation to the *Physikalische Zeitschrift* more than a year ago, but at the date of writing, April 1930, it had not appeared.

pressure, discovered a little earlier, were equally significant. Einstein a couple of years later set up this interconvertibility as a general consequence of the special theory of relativity,[11] and from that time forth it was available to every one who like Prof. Moulton was seeking a new source of energy for interpreting stellar lifetimes. Certainly within less than a decade from that time it had become the subject of common table talk about the University of Chicago. Further, so soon as in 1913–14 the Moseley relations and the facts of isotopes became established, atom-building within the stars with the transformation into radiant energy of the 0·0078 gm. which disappears for every gram-atom of hydrogen that goes over into helium, then thought because of alpha-ray phenomena to be the intermediary by which hydrogen is built into the structure of the heavier elements, became a universally recognised source of stellar heat. Harkins (*Phil. Mag.* **30**, 723, 1915) discussed at great length this loss of mass, or 'packing effect', in atom-building. I reviewed it in the first edition of my little book "The Electron", p. 203, published in 1917. Its insufficiency to account for the whole of stellar energy was pointed out later. In a letter to NATURE (**99**, 445; 1917) Eddington mentions the idea of the entire annihilation of matter by the falling together and the complete overlapping of the fields of positive and negative electrons and ascribes the idea to Jeans (NATURE, **70**, 101; 1904).

Thus, certainly so early as 1915 the idea of atom-building out of hydrogen as a source of stellar energy and, so early as 1917, the idea of atom annihilation as a more potent source of such energy, had found their way definitely into the literature of physics and had presumably been current in physical laboratories other than that at Chicago from still earlier periods, for they are both obvious deductions from the Einstein equation (1905) and the facts of isotopes (hydrogen having an atomic weight of 1·008 instead of 1).

In our discussions at Chicago, W. D. MacMillan in particular always insisted on going one step farther and on abolishing the idea of the 'heat-death' by assuming that atom-building took place *in outer space* through the condensation there of radiant energy into atoms. He discussed this with me fully in 1915, and in July 1918 [12] he published these ideas in full. Any one interested in the history of this subject should read his other articles,[13] for he has been the chief advocate from the theoretical side of the idea of the evolution of cosmical energy through atom-building processes.

These three ideas, then, (1) atom-building out of hydrogen, (2) atom annihilation, and (3) the possibility of the condensation of the energy of radiation into atoms, especially the first two, are the ideas which we have subjected to certain sorts of *experimental* tests in our cosmic ray work. We have heretofore not been concerned at all with assigning priorities as to their *speculative* inception, and have made no attempt to do so, since our task has been merely to show how our experimental results bore upon these now widely current conceptions. We put forward the first bit of quantitative experimental evidence from the point of view of the cosmic rays when in 1925 we pointed out that our highest observed wave-length corresponded, according to our mode of computation used at that time, exactly to the energy resulting in accordance with Einstein's equation to the formation of helium out of hydrogen, and in February 1927 we discovered much more trustworthy evidence that this process, and also certain other atom-building processes, are the actual cause of the cosmic rays.[14] Furthermore, we presented evidence to show that contrary to all preceding assumptions, so far as we can discover, unless it be MacMillan's, *these particular atom-building processes do not appear to be taking place in the stars at all, but rather in the depths of space*. If there is any one in the world, next to Einstein, who pioneered in developing the *theoretical* ideas for which we have found a certain measure of experimental support, it is W. D. MacMillan. Every one who after 1918 has attempted or shall attempt to record the history of speculative ideas about atom-building in cosmic processes should certainly make reference to his work.

So much for the early history of atom-building ideas as I have personally come into contact with them. They may have been developed independently in other places also, but if so I have known nothing of it.

Now as to the experimental history of the penetrating radiation, a part of which is now known to be due to cosmic rays. This was what Dr. Cameron and I presented as accurately and as fairly as we knew how to do in the brief time available in the particular address published in NATURE in 1928 that is criticised in the foregoing reference, and I hope that my readers will all read it for the sake of judging both of its spirit and its facts. Any additions that need now to be made can best be grouped about the answers to the criticisms.

The address itself was one which I was asked to give as a popular evening lecture before the British Association for the Advancement of Science at Leeds in September 1927. It consisted in a report upon the then recent work of Dr. Cameron and myself on cosmic rays. In presenting our "New Results", I was very careful to avoid giving the impression that our work stood all by itself, and to emphasise this point I told my audience that my subject presented "a very beautiful illustration of the slow step-by-step process by which most advances in science are made, each experimenter building upon the past, but pushing on, if he is fortunate, a little beyond where his predecessors had gone", etc. I did this solely for the sake of disclaiming undue credit to ourselves for the work that was to be presented, and at the same time of stating a profound truth generally overlooked by the public, and actually one extraordinarily well illustrated by this subject, as even a superficial familiarity with its history will reveal to any unprejudiced observer. I had no thought of discrediting, and did not in any way discredit by that statement, as I am assumed in the foregoing review to have been attempting to do, the work of any of

my predecessors, the essential elements of whose contributions I then proceeded to state precisely as the record, as I read it, reveals them.

Dr. Kolhörster was in the audience, and afterward in friendly private conversation suggested no corrections and made no adverse comment of any kind, so that whether he was in complete agreement with my reading of the records or not I had every reason to suppose that his spirit was friendly. Also, so far as the historical introduction to that address is concerned, the spoken address was essentially the same as the written address, save for the insertion of the references in the footnotes. Since that time, however, the spirit of distrust and suspicion seems to have developed to such an extent as to call forth the exceedingly ungenerous and untrue charge that we have deliberately borrowed ideas from Nernst and from v. Schweidler without giving them credit. ("Die Ergebnisse dieser beiden Autoren werden von Millikan and Cameron Duchweges benutzt aber nirgends citiert.")

Now, the facts are that I have never seen a word written upon this subject by my friend and former teacher, Prof. Nernst, and knew only from Dr. Kolhörster's articles, and very recently from Prof. v. Schweidler's excellent book "Radioactivitat", page 607 *et seq.*, published in 1927, that Prof. Nernst had suggested a localised origin of the rays, which was not in keeping with our own findings of their uniform distribution throughout the heavens. Therefore, for the sake of not directing attention to a divergence of views as to origins, or asserting the incorrectness of any one's conclusions, I contented myself with merely stating briefly the experimental fact that Dr. Cameron and myself had brought to light thus far "no directional effect in cosmic rays at all", which is "at variance with results reported by Büttner and Kolhörster". It would be difficult to find anywhere a more complete inversion of fact or of motive than that existing between the real situation and the situation implied in the critique of Dr. Kolhörster *et al.*

Further, as to borrowing theoretical ideas from Prof. v. Schweidler's able writings, we have not only never attempted to advocate or even discuss the view attributed to him of a "gleich mässig verteilten strahlender materie", but also we were not pretending in the article in question to be doing anything more than presenting our *new experimental evidence* which we, at least, had found very helpful in enabling us to differentiate definitely between the three possible theoretical hypotheses which had been discussed so repeatedly as to have become common property so early as 1909, and were variously favoured by different competent workers [15] up to 1926, namely:

1. The hypothesis of an extra-terrestrial origin;
2. That of a radioactive stuff spread through the upper atmosphere; and
3. That of a radioactivity spread through the earth's crust.

It is hoped that any one who is interested in the history of this field will read the long summary and review, citing some scores of preceding articles that had already appeared by 1909 (*Physik. Zeitschr.*, **10**, 836; 1909). The reviewer, Kurz, discarded the first hypothesis, which he correctly attributed to Richardson, 1906, and also the second, and adopted the third as satisfying all the then known requirements, a conclusion which for the first time became completely untenable because of Gockel's balloon observations in 1910 and 1911, observations in which in three different balloon flights, all yielding results in substantial agreement, it was definitely shown that the ionisation within an air-tight vessel is larger, as we stated, at high elevations (up to 4500 metres) than at low, while Kurz and others had by 1909 presented definite tabulated computations showing that with the earth as the source the ionisation would have to fall to practically zero in going up as much as a thousand metres. Gockel's actual readings taken in two flights with electroscopes definitely arranged to maintain the pressure of their surroundings, in the third presumably doing so unintentionally, and so interpreted by him,[16] were sufficient completely to justify as a whole the statement which we made and which our authors criticise. Indeed, we took this statement directly from Gockel himself, as well as from Hess,[17] for the latter says, "Gockels Messungen ergeben, wenn man auf normalen Luftdruck korrigiert, sogar eine schwache Zunahme der Strahlung mit der Höhe".

Further, the point of real significance here is simply the fact that the readings did *not* fall at all to zero at altitudes above 1000 metres, as they were obliged to do, as shown repeatedly so early as 1909, if the earth were the source of the observed effect, thus definitely disproving the hypothesis most generally favoured up to this time and forcing a return to one or the other of the hypotheses rejected by Kurz. We certainly then did not do anything but state the simple fact in saying that this was "the next important step" after 1903. Gockel is now dead and cannot state his own case, but this is the more reason for urging all interested to read the record and let it speak for itself. The next year Hess,[18] after repeating and checking Gockel's experiments, extending them to 5200 metres and making them more *quantitative*, spoke definitely in favour of a return to hypothesis No. 1, although suggesting also the possibility of No. 2,* and Kolhörster also favoured No. 1, in interpreting his experiments of 1913 and 1914.[19]

There were no more observations of any kind significant for this history, at least that I know of, until March and April 1922 when Bowen and I [20] made our high sounding balloon flights (15·5 km.) for the sake of subjecting to a severe and crucial test hypothesis No. 1 now supplemented by v. Schweidler's [21] definite calculation from Hess and Kolhörster's most consistent data of $\mu/P = 0{\cdot}57$ per metre of water on the hypothesis that the rays

* Wigand in a comprehensive and admirable review (*Physik. Zeitschr.*, **25**, p. 13; 1924) summarises the situation up to 1924 as follows: "Die Hypotesen über den Ursprung der durchdringenden Höhenstrahlung sehen die Strahlungsquelle entweder ausserterrestrisch im Kosmos oder in den höheren Schichten der Erdatmosphäre (Hess, 28, 33), v. Schweidler, Seeliger. Aus dem mannigfachen Für und Wider lässt sich noch kein klares Bild erkennen, und man muss vorerst noch mit mehreren Möglichkeiten rechnen." Those interested in understanding the facts developed up to 1924 should read this article in full.

(*Continued on p.* 29.)

Supplement to NATURE

No. 3166 JULY 5, 1930

The Metal Crystal.*

By Sir HAROLD CARPENTER, F.R.S.

WHEN prepared by one of the usual methods, metals and alloys consist of an aggregate of small allotriomorphic crystals. Pure metals usually consist of a large number of similar crystals. Alloys are sometimes composed of one type of crystal, though usually they contain two or more different kinds. In both cases metals as ordinarily prepared contain anything from about one hundred thousand to several millions of crystals per cubic inch. In all metals, however, the individual crystal is the unit of which the aggregate is built. It is therefore the simplest form of metal.

The size and shape of the crystal depends on the type of mould in which the fluid metal is cast and on the rate of cooling, and in any given casting crystals of various types may be obtained. In the casting of a steel ingot, for example, a layer of 'chill' crystals form in contact with the surface of the mould. Attached to these, columnar crystals grow nearly at right angles to the surface, while in the interior, equiaxed crystals result, which are due to the separation of minute crystals in the liquid which grow and form interference boundaries (Fig. 1). In addition to these, skeleton crystals grow on the surface and sometimes also in the cavity produced by shrinkage in the upper part of the ingot. During the subsequent mechanical treatment to which the metal is subjected, these crystals change their shape. If the mechanical work is severe, they are fragmented and eventually complete recrystallisation takes place with the birth of new crystals. Whether, therefore, a given metal or alloy is used either as a casting or in some worked form, it always consists of an aggregate of crystals.

The properties of metals and alloys in the ordinary state, accordingly, are the properties of these *aggregates*. As already mentioned, the individual crystal is the unit of which these aggregates are composed. Even if it possessed directional properties, these would not be revealed by any tests on polycrystalline material, since the individual crystals are oriented in many directions, and the directional properties would be cancelled out. In addition to this, however, the properties of the crystal boundaries themselves have to be considered. The finer the aggregate, the larger the area occupied by the boundaries. It has long been known that the boundaries in a crystal aggregate are stronger than the interiors of the crystals. For example, a metal fractures under tensile test through and not round the crystals. One of the commonest methods of increasing the strength of a metal or alloy is to diminish its crystal size and increase its boundary area by suitable thermal and mechanical treatment. The properties of any given metal, therefore, are the resultant of those of the very numerous individual crystals of which it is composed, oriented in many positions, modified by the properties of the crystal boundaries.

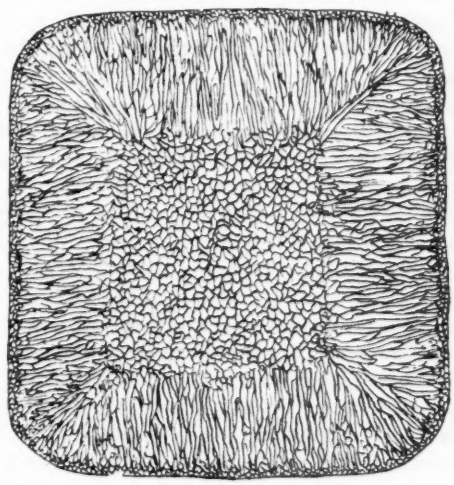

FIG. 1.—Section of steel ingot showing three types of crystals. Outside layer, small chill crystals. Intermediate layer, columnar crystals. Inside layer, equiaxed crystals.

If it were possible to study the properties of the individual metal crystal, the variables which have just been mentioned would be excluded, and the observations made would be of fundamental scientific value. Any particular property of the metal crystal itself could be studied, the only

* Discourse delivered at the Royal Institution on Friday, May 30.

variable being its orientation. It would thus enable the test to be made whether the property in question was directional. From a scientific point of view, therefore, the study of individual metal crystals should precede that of aggregates. Owing to the fact, however, that special conditions have to be observed if a metal is to be obtained in the form of a single crystal, the order of investigation has in practice been just the opposite.

It was the realisation of this fact which gave rise about twelve years ago to definite attempts on the part of investigators to prepare single metal crystals. Considering its great scientific importance, it is perhaps surprising that the attempt was not made earlier, but it is clear that it could not have been made with any real prospect of success until the technique of metallographic research had reached the necessary stage of perfection.

Looking at the problem of preparing a given piece of metal in the form of a single crystal, it is theoretically capable of solution in at least three different ways :

(1) By production of the crystal from the vapour phase.

(2) By its production from the liquid phase.

(3) By the conversion of the solid metal in the ordinary polycrystalline aggregate into a single crystal.

Success has been achieved in each of these ways. To-day there are nine methods of producing single metal crystals—two from the vapour, three from the liquid, and four from the solid phase. Each of these is an example of what may be called *controlled* crystallisation, and the investigation of any particular metal divides itself into three parts : (*a*) The production of the crystal itself ; (*b*) the determination of its orientation ; and (*c*) the study of its properties. The last category may be divided into two sub-categories, according as the investigation either does or does not involve the distortion of the crystal.

Production of Single Crystals from the Vapour Phase.

Two methods are available, each of which is based upon the technique developed in the incandescent lamp industry for depositing tungsten metal on a glowing wire. One is due to Koref,[1] the other to Van Arkel.[2] Both methods start with a single crystal obtained by another method. This serves as a nucleus and grows to a large single crystal. As an example the production of single crystals of zirconium by J. H. de Boer and J. D. Fast [3] may be described. There is a special interest about this method in that not merely has it enabled this metal to be produced in the monocrystalline form, but also that it has for the first time led to its production in the pure state, in which, whether mono- or polycrystalline, it is ductile, whereas as previously prepared it has always been found to be brittle. This is now known to be due to small traces of impurities.

The principle of the method is the deposition on a glowing metal filament of the metal in question by the thermal dissociation of a volatile compound. The essential condition for success is that below the melting point of the metal to be prepared a temperature range must exist in which the vapour pressure of the metal is smaller than the partial pressure of the metal in the vapour phase. In this particular case the metal filament consisted of tungsten and the compound in question was zirconium iodide. It is not necessary to prepare the iodide at the outset. A mixture of zirconium and iodine will do equally well. The tungsten filament, the diameter of which is about 40 μ, is heated by an electric current to a black-body temperature of 1800°, as read by an optical pyrometer. The reaction vessel made of pyrex glass is then placed in an electric furnace and heated to about 600° C. The zirconium powder and iodine combine to form the iodide and this compound then sublimes. It is decomposed by the filament at 1800° C. and the zirconium deposited on it. Free iodine is than available to combine with a fresh quantity of zirconium in the reaction vessel and the cycle of changes is repeated until sufficient metal has been deposited. The filament is cooled by the solidification of the zirconium and from now on the temperature has to be measured through the strongly coloured vapours of iodine and the iodide. The success of the experiment depends upon depositing zirconium at the correct temperature. This has been found to be about 1800° C. The current rises from an initial value of 0·25 for a filament of 40 μ to 200 amp., when the metal has grown to a diameter of 5 mm. Whether the temperature of the filament falls or rises during the experiment depends upon the external resistance. If this is small the strength of the current is determined by the filament itself. As this grows its resistance falls in proportion to the square of the diameter, whereas cooling by radiation is proportional to the diameter. Therefore, the temperature of the filament tends to rise, and this must be prevented by increasing the external resistance. Conversely, if the external resistance is large, this determines the current, and the zir-

conium rod, which is continually becoming thicker, tends to cool.

If the temperature of the filament is kept at 1700° C., the zirconium deposited is polycrystalline. Between 1750° and 1850° C. the crystals of zirconium are so large that only one occurs in the cross-section of the wire and the built-up rod consists of a series of single crystals of from 0·5 cm. to 1·5 cm. long built round the tungsten nucleus. The crystals thus formed are found to be hexagonal prisms. If the temperature is allowed to rise to 1900° C. the zirconium grows very rapidly at first, but before long it reacts with the tungsten filament and forms a eutectic.

This method is suitable for preparing single crystals of the high-melting lamp filament metals. Van Arkel and de Boer have applied it to titanium, hafnium, and thorium. Koref in co-operation with Fischvoigt [4] has succeeded in preparing single crystals of molybdenum, tantalum, iron, zirconium, and titanium by his method. It is possible, therefore, by either of these methods to prepare single crystal wires and thin rods of high-melting metals, provided the vapour of the compound of the metal with iodine satisfies the condition described above.

Production of Single Crystals from the Liquid Phase.

Brief mention may be made of two of the methods available. These have been used mainly for preparing single crystals of low-melting metals in refractory glass containers, but they can also be applied to metals and alloys of higher melting points in suitable containers.

The first method is that devised by Czochralski,[5] who prepared long thin threads of crystals by drawing them out at a particular rate from the molten metal contained in a crucible just above the freezing temperature. The metal is drawn upwards by means of an auxiliary wire moving vertically at a uniform rate. At some millimetres above the surface of the molten metal solidification begins. The rate of movement of the auxiliary wire has to be the same as the speed of crystallisation. If it is too quick, the single crystal wire breaks ; if too slow, polycrystalline wires are produced. In this way single crystal wires (0·5 mm. diameter) of tin, lead, and antimony have been prepared. This method was developed further by Gompers (1922) and Mark, Polanyi and Schmit (1923).

Single crystal rods up to one inch in diameter can be grown by the second modification due to the work of Tammann (1923), Obreimow and Schubnikow (1924), and Bridgman (1923–25). In Bridgman's method the molten metal contained in a suitable closed tube of refractory glass or quartz is slowly lowered through a tubular electric furnace in a vertical position, and kept at a temperature somewhat above the melting point of the metal in question. The lower end is tapered to a point, which is the first to emerge from the furnace. Solidification starts here and proceeds slowly upwards. Provided the rate of lowering is less than the velocity of crystallisation and sufficiently slow for the latent heat of solidification to be dissipated by conduction, the metal usually crystallises as a single crystal, and in this way Bridgman prepared single crystal bars of tin, cadmium, zinc, antimony, bismuth, and tellurium.

This method depends for its success upon the formation of only one nucleus, upon which the solidifying metal crystallises uniformly. If, however, crystallisation starts from more than one centre, then some means must be found of confining the growth to one crystal. The best way to meet this difficulty was found to be by drawing the lower part of the tube out into a separate chamber separated from the main part by a capillary 0·1 mm. in diameter. This acts as a filter and allows only one of the several crystals which may have formed initially in the lower bulb to get through into the main part of the tube. It is this crystal which then grows and forms the single crystal test-piece.

Bridgman's experiments were carried out by allowing the crystal to form *in vacuo*, and the elimination of all dissolved gas is therefore an essential condition of the success of this method. The rate of lowering depends both on the metal and the size of the tube. In the case of bars 2·2 cm. in diameter, a speed of about 4 mm. an hour was found to be suitable. For bars of small diameter, however, speeds up to 60 cm. per hour could be employed.

The removal of the single crystal bar from the tube is an operation requiring great care. If the containing vessel is perfectly clean, the metal sticks and cannot be removed without distortion. The tube must therefore be greased. A convenient way to do this is to flush out with a heavy mineral oil and then wash this out with petroleum ether. The tube is then heated so as to remove the ether, but a thin film of oil clings to the glass and is sufficient to prevent the metal from sticking.

Davey [6] modified Bridgman's method by using a graphite tube, and succeeded in making single crystal copper test-pieces six inches long and nearly

one inch in diameter. Miss Elam [7] has shown that single crystals of copper, silver, and gold can be grown in graphite tubes in an atmosphere of nitrogen. This has proved to be an advantage, since when grown in this way the metals are quite sound, whereas if melting is carried out *in vacuo* there is a liability for the resulting rod to contain blow-holes. Here also the greatest care is required in removing the crystals, particularly of soft metals, from the containing tube. On one occasion it was found on removing a single crystal rod of gold that it was twisted into a spiral showing three complete turns.

Production of Single Crystals from the Solid Phase.

The problem here consists in the conversion of a polycrystalline into a monocrystalline metal. Success has been reached in this case by the utilisation of an observation made by Sauveur [8] in 1912. He showed that by carefully straining and afterwards heating certain metals, crystals of a larger size could be produced, and suggested that there was a *critical stress* which produced the largest crystals. Later, Ruder,[9] Chappell,[10] Jeffries,[11] and Hanson [12] have shown that if a metal is locally deformed and then heated, exceptionally large crystals form at some distance from the point at which the stress is the severest. If a tapered test-piece is used, a strain gradient is obtained, and the largest crystals always form within the strained region, but farther from the area of greatest strain the higher the temperature. Seligman and Williams [13] stretched aluminium sheet which had previously been heated to various extents and found on heating that, up to a certain point, a small deformation had no effect. Beyond this point, however, large crystals were formed, and as the deformation was further increased the crystal size was diminished. The crystals produced by these methods were very large compared with those in the original metal, some of them being 0·5 in. long.

Single crystal test-pieces were first produced from the polycrystalline metal in the case of aluminium by the following series of treatments : [14] (1) The metal has first to be softened completely, recrystallised, and converted into new equiaxed crystals so far as possible of uniform size. The most suitable size has been found to be 36 per square millimetre. This condition was produced by heating the metal for six hours at 550° C. (2) These crystals must then be strained to the required amount. The precise degree of strain for the aluminium used was an elongation of 1·6 per cent on three inches, produced by a tensile stress of 2·4 tons per square inch. (3) The strained crystals have afterwards to be heated in such a way that the potentiality of growth conferred by strain can be brought fully into operation. This final heat treatment was begun at 450° C., and the temperature raised about 25° C. per day up to 550° C. It was finally raised to 600° C. for one hour in order to complete the absorption of small crystals on the surface which persistently remained at lower temperatures.

The boundary of the single crystal thus produced extends at each end in the form of an irregular surface into the head of the test-piece (Fig. 2), and by

Fig. 2.—A. Test-piece consisting of two crystals, end to end. B. Test-piece consisting of single crystal. The boundary extends at each end into the broad head of the test-piece. One-third natural size. (Reproduced by courtesy of the Institute of Metals.)

this means single crystal bars of aluminium have been prepared, the diameter of which was 0·564 in. and length about 8 in. Polycrystalline bars 0·798 in. in diameter have been converted into single crystals over a length of 4 in. In this way, upwards of seven million of the original crystals can be caused to coalesce into a single crystal. How delicate the process of adjustment of strain is may be judged from the fact that its precise value has to be determined for each fresh batch of aluminium even though the metal is of the same 'works' composition. On an average, one experiment in four succeeds in producing a single crystal test-piece. To give one illustration : the result of

treating a batch of twenty polycrystalline test-pieces was that seven were converted into one crystal, eight into two crystals, four into three crystals, and one into four crystals.

This method has been successfully applied by Edwards and Pfeil [15] to the production of large crystals of iron. It has also been utilised by Miss Elam [16] in the production of single crystals of solid solution alloys of zinc in aluminium. Schaller and Orbig have used it to prepare single crystals, wires of tungsten and molybdenum, while Altertum has prepared single crystal bars of tungsten by making use of the peculiar effect steam has on small tungsten crystals at high temperatures.

The production of single crystal test-pieces from polycrystalline metals by the method of critical straining followed by heating is a more complex process than that of the preparation of single crystals direct from the vapour or the liquid.

The deformation of a metal is possible on account of the existence of 'atomic planes' in each crystal. These are planes which can glide and slip along each other. In a single crystal bar where the orientation is uniform these planes function unhindered. In a polycrystalline bar, however, where the crystals are variously oriented, the movements are quite different. The first crystals to yield are those so oriented that they display the least resistance to stress. The degree of this is limited since they are held in a rigid matrix of other crystals. Hardening takes place along the slip planes and the movement is finally arrested. Limited slip then takes place on other crystals which now present the least resistance to the stress, and they in their turn are hardened. The process is then repeated in other crystals. The net result is that in this case the planes of slip are not uniform but bent. According to van Liempt,[17] "In this way strains are produced in the crystal because the original distance of the atoms has not remained quite the same and the electron lattice has been distorted. The deformed metal is now in a labile condition. The lability is locally the greater as the strain increases. If the deformed metal is now brought to a high temperature there will be an inclination to return to the stable condition."

The method of critical straining consists in straining the crystals of an aggregate in such a way that when it is heated only one of the crystals recrystallises and forms a nucleus. On continuing the heating, the remainder of the crystals, which are in a labile condition, gradually recrystallise and aline themselves on the single nucleus. Ultimately, therefore, a single crystal bar is obtained. If, however, the bar were heated at a higher temperature, a number of strained crystals would recrystallise forming nuclei, and each of these would act as a crystallisation centre. The result would be a bar containing as many crystals as there were nuclei. The reason why in any given set of experiments only some of the bars become monocrystalline is that it is not always possible to ensure that only one labile crystal recrystallises in the first instance. This method, in fact, permits crystals of any desired average size to be grown from a polycrystalline aggregate, since it is only necessary to adjust the degree of strain and the temperature to the requisite condition. In this respect it is the most general of the methods available for preparing large crystals. Moreover, it is quite independent of the melting point of the metal or alloy. In another sense, however, it is more restricted since it depends on the response of the crystal lattice to stress and the liability of the metal or alloy to form twin crystals on being heated. If such liability exists, single crystals cannot be prepared by this method.

Orientation of the Crystals in Single Crystal Test-pieces.

The only satisfactory method of determining the orientation of the crystals is by X-ray analysis. The original method of determining the crystal axes was worked out by Müller.[18] It involves the preparation of bars of square section and the photographing of the reflections from the crystal planes. A special arrangement is required for mounting the bar so that it can be rotated on a vertical axis and photographed in the desired positions. Müller found that the reflections from unstrained bars are perfectly clear and sharp and are obtained within a narrow setting angle, whereas, if the bars are strained, the reflections become 'fuzzy' and are spread over a wider setting angle, the width of which increases with the extent of the distortion. In Müller's method the data can only be obtained for a very thin surface layer of the test-piece. The measurements which he made, however, on the various parts of the surface, showed that this layer had the same orientation relative to the reference plane over the whole surface. It seems probable, therefore, that the same thing holds for the entire rod.

I will now deal briefly with two questions to which the method of X-ray analysis gives definite answers: (1) Are the single crystals obtained in the various ways I have described perfect crystals in the sense that the orientation of their atoms is

uniform corresponding to the crystal symmetry, and are they free from strain? It will of course be realised that owing to their method of preparation they cannot, with one exception, possess the external forms but only the internal symmetry of crystals. The particular exception to which I refer is the case in which they have been produced from vapour, and here, provided suitable conditions are maintained, the crystal wires do show the external forms of crystals. So far as they have been tested, single crystal rods and wires prepared either from the vapour or the liquid phase show themselves perfect crystals when tested by X-ray analysis. This is very much what is to be expected, at any rate in the latter case, since the crystals have been deposited from the liquid by slow cooling under conditions in which no strain should be produced. But it is interesting that the reflections obtained from aluminium single crystal test-pieces, grown from the polycrystalline solid by the method of critical straining and heating, are also perfectly sharp and indicate the complete absence of strain, at any rate so far as the external layers of the crystals are concerned. It follows from this that the small strain set up in their production is completely removed by the prolonged heat-treatment to which they are exposed. This conclusion is supported by the fact that when such bars are slightly distorted the X-ray reflections immediately become less clear.

(2) Do the crystals grow more easily in certain positions than in others; that is, do they take up a preferential orientation? As yet no evidence is available on crystals deposited from the vapour phase. Bridgman concluded that the favoured position of growth from the liquid is that in which the principal cleavage plane is parallel to the axis of the crystal, and he has stated that in the case of large crystals of antimony, no specimens were found which were oriented in any other way. This, however, does not fix the orientation of the crystal, since this plane of cleavage may have any orientation within 180° about the axis of the casting. Miss Elam has shown that in the case of rods of copper, silver, and gold, grown from the liquid, there is no particularly favoured position. Considerable variations of position have been found by her in the case of crystals grown by the method of strain and heat-treatment, and the evidence on this point is now quite extensive.[19] Twenty-nine aluminium, twelve aluminium-zinc alloy, and ten iron single crystal test-pieces have had their orientations determined. In the case of aluminium, a great variety of orientation was met with, since the positions of the axes were found to be scattered over a wide field, but the majority of the crystals favoured a position near the (110) axis, and none has yet been obtained near either the (111) or the (100) axis (Fig. 3). Moreover, this was also found to be the case for an aluminium test-piece consisting of four crystals. In the aluminium-zinc alloy, a considerable variety of orientations was also found, but here it was the (110) axis which was avoided. Five out of twelve crystals were found to be near the (100) axis. In the case of iron a wide range of positions was found among the ten crystals. The (110) axis was avoided, but no evidence was found of any preferential orientation.

Summing up the evidence, it is clear that in the

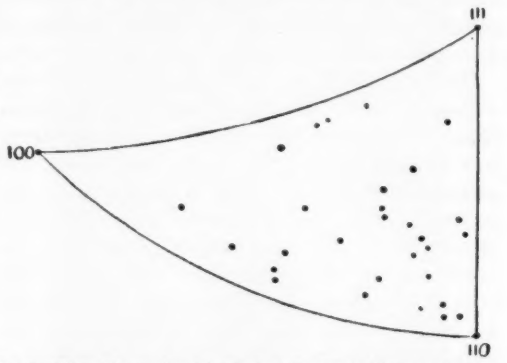

FIG. 3.—Shows the great variety of orientations met with among twenty-nine single-crystal test-pieces of aluminium. 111 (octahedral); 110 (rhombicdodecahedral); 100 (cubic).
(Reproduced by courtesy of the Institute of Metals.)

case of the fifty-one crystals, the positions of which have been thus determined, the method of straining and heat-treatment does not determine to any marked extent the orientation of the crystals which grow although certain orientations are avoided. Growth appears to be equally easy in a great variety of positions. The orientations which are avoided are no doubt those in which growth is more difficult. The problem of growing a single crystal test-piece in a desired orientation has been recently taken up and a certain measure of success has been obtained.[20]

Mechanical Properties of Single Crystals.

I have already had occasion to comment on the remarkable softness of single crystal bars, which necessitates great care in their handling and machining, and differentiates them from the same metals in the polycrystalline form. This is precisely what we should expect from a metal possessing the uniform orientation of a single crystal and constitutes strong evidence that the bars really

are single crystals. It has been known since the work of Ewing and Rosenhain at the end of last century that the plastic yielding of a metal is due to slip on certain planes along which it yields more easily than in other directions. Even so, the ease with which single crystal bars of aluminium, copper, silver, and gold, and even iron, can be deformed is astonishing. Each of these metals can be bent very readily, but once it has been bent to any marked extent, a higher stress is required to make it revert to its original shape. This simply means that it has been hardened under distortion and the uniform crystal pattern of the atoms altered. Whether this is due, as Miss Elam and I have suggested, to the uniform bending of the crystal planes, or whether, as Gough, Hanson, and Wright have suggested, the distortion of the crystal plane is such that the average curvature is small and of the nature of 'rumpling', cannot as yet be decided.

The softness of single crystal bars indicates that they can only possess a very low limit of proportionality under stress, and indeed raises a doubt whether they can properly be described as possessing any limit of proportionality at all. This point has been carefully tested by Gough, Hanson, and Wright [21] in the case of the metal aluminium. The limit of proportionality in tension of a polycrystalline bar is just about one ton per square inch. These investigators found that the single crystal bars possess no primitive limit of elasticity, but plastic straining occurred under the least stress applied. Furthermore, they conclude from the slope of the stress-strain diagram, even at the 10-40 lb. range of load, that no primitive state of elasticity existed. It is clear, therefore, that the well-defined elastic limit found in the polycrystalline bar is not a property of the metal crystal, but of the crystal aggregate in the case of aluminium.

The common and useful metals belong to one of three types of crystal structure, the face-centred cubic, the body-centred cubic, or the close-packed hexagonal lattice, and it is significant that each of these represents a very high degree of crystal symmetry. These have certain structural features in common. Planes of atoms exist in which the units are closer together than they are to their neighbour in the next plane. Even in the same plane, however, there are certain lines in which the atoms lie closer together than they do in other directions. When a crystal is stretched or compressed it tends to yield on certain planes and along certain directions in which the forces binding the crystals together are the weakest.

Single Crystals of Aluminium.

The deformation and ultimate fracture of a single crystal test-piece was first carried out in the case of the metal aluminium. The first experiments were qualitative, and showed at once that the tensile properties of this metal are directional. On one hand, a round polycrystalline bar pulls out like an isotropic material. It undergoes general extension, and finally breaks with considerable reduction of area and yields a cup and cone fracture (Fig. 4).

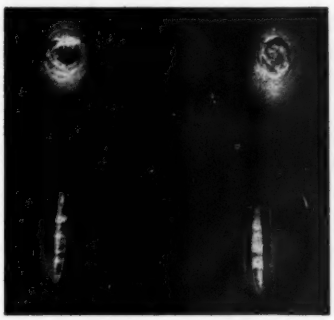

Fig. 4.—Upper half, fracture of polycrystalline test-piece yielding cup and cone fracture. Lower half, fracture of single-crystal test-piece yielding 'wedge' fracture.

This is the result of bent slipping. The cross-section of the test-piece is round at any point, although the surface is roughened, due to the unequal distortion of the minute differently oriented crystals. On the other hand, when a round single crystal bar is distorted under tensile stress, it becomes an ellipse. As distortion proceeds the ellipse becomes sharper and sharper. A point is reached when a curious and characteristic lens-shaped figure, inclined at an angle to the long axis of the test-piece, makes its appearance. Finally, the bar breaks at this point with a characteristic 'wedge' fracture (Figs. 4 and 5). In this test the surface of the test-piece is not roughened, but is mechanically etched with numerous slip lines, which are known as 'glide ellipses'. Considerable variations in the ductility and ultimate stress of different test-pieces are found to be due to differences in the orientation of the single crystal, relative to the axis of the test-piece. The ductility is in some cases nearly three times as great as in the polycrystalline bar, whereas

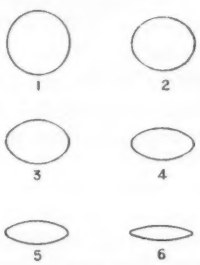

Fig. 5.—Shows stages in the reduction of a round single-crystal test-piece of aluminium in a tensile test leading to the production of a 'wedge' fracture.

the ultimate stress is considerably less and in no case exceeds 80 per cent of that of the polycrystalline metal.

The first complete mathematical and quantitative analysis of the distortion of a single metal crystal was also carried out on aluminium, and forms the subject of the Bakerian Lecture by Taylor and Elam in 1923.[22] The analysis was carried out on a square bar machined from a round bar and involved the marking of each face with a scratch parallel to the length of the axis of the specimen, and by cross scratches at 0·5 in. intervals. The dimensions of the test-piece were 1·0 cm. × 1·0 cm. × 20·0 cm. The faces were numbered 1, 2, 3, 4, so that when the specimen was placed upright in the testing machine the faces appeared in this order when the observer moved round the machine in an anti-clockwise direction. At each successive stage of the test, the extension between each pair of cross marks was measured on each face. The angles between cross scratches and longitudinal scratches were also measured. In addition, the thickness of the specimen between the pairs of opposite faces, and the angle between neighbouring faces, were also measured. These sufficed to determine the nature of the distortion (Fig. 6).

These investigators found that up to an extension of 40 per cent elongation the crystal distorted by slipping or shear on one plane. This plane was found by X-ray measurements to be an octahedral plane (111) of the crystal. The direction of shear was also determined and found to be along one of the three principal lines of atoms in the octahedral plane. When the specimen was extended beyond 40 per cent elongation, it was found that the distortion was no longer due to slipping on one plane. This was explained by the authors, who showed that the effect of the shear was to rotate the axis of the specimen relative to the crystal axes in such a way that another octahedral plane came into a position where its inclination to the axis was the same as that of the slip plane. In these circumstances it was clear that slipping might occur on both planes simultaneously, and it was verified that this was the case (Fig. 7).

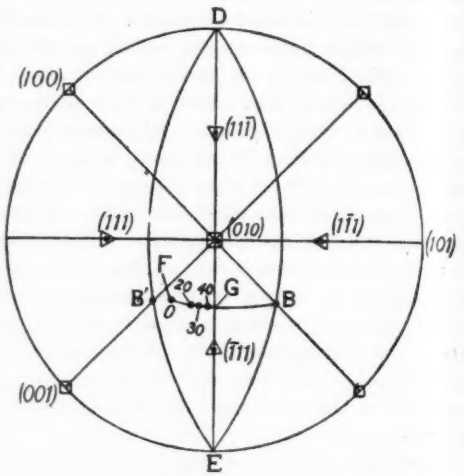

FIG. 7.—Shows the position of the axis of the specimen relative to the crystal axes at 0%, 20%, 30%, and 40% extension. (Reproduced by courtesy of the Royal Society.)

This investigation furnishes the explanation of the drawing down of round single crystal test-pieces of aluminium in the tensile test into very acute ellipses. It is due to the slipping of the crystal on two conjugate planes. It also established a further important point. Hitherto, the evidence with regard to the yielding of a metal by slip had been purely qualitative. It had not been shown that the deformation when a metal crystal is strained is such as could be produced by slip. The quantitative measurements in this paper showed for the first time that this is the case, and it has been left to Taylor and Elam to complete in this way the original discovery of Ewing and Rosenhain.

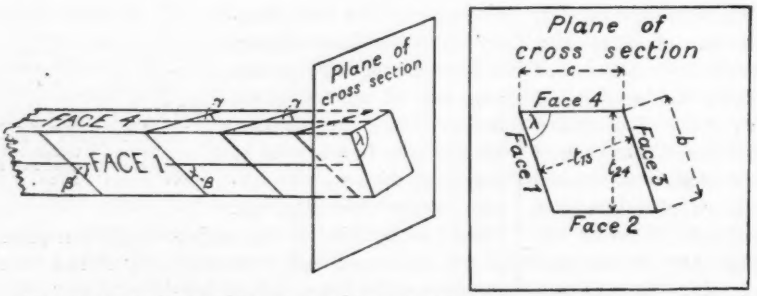

FIG. 6.—Scheme for marking and measuring the distortion of a single-crystal test bar of aluminium. (Reproduced by courtesy of the Royal Society.)

The second paper by Taylor and Elam,[23] on the plastic extension and fracture of aluminium crystals, contains a most interesting test. Previously they had analysed in a similar way the distortion of other single crystal bars in which slipping

begins on one plane and afterwards continues on two, when the bar has moved into the position of conjugate slipping. They predicted that if the crystal axis of the unstrained crystal were originally in the position where double slipping could occur, it should begin at once. Among the large number of crystals grown by Miss Elam and myself, one was found the axis of which corresponded very closely to this position. On distorting this in tension, it was found that double slipping began almost at once and continued throughout the whole of the remainder of the extension. Not only this, but also the amount of slipping which occurred on the two planes was practically equal and the axis of the specimen scarcely changed during the whole of the test. One other conclusion also follows from these tests, namely, that whatever the original orientation of the crystal in the test-piece, it always breaks in the same position.

The question then arises, does the single crystal remain a single crystal throughout the extension up to fracture, or does it break up? Evidence on this point is contained in Müller's paper (loc. cit.) in the character of the spots reflected by X-rays. In the unstrained specimen the reflected spots are very small and only obtained within a small setting angle. When extension began the range of reflection frequently increased, and the size of the reflected spots became larger. Assuming that the material does break up into small crystals, it is possible from the dimensions of the reflected spots to make a rough estimate of the maximum angle between the surfaces of a pair of these small crystals. It was found that this angle amounted sometimes to several degrees. Müller infers that this result shows the actual breaking up of the test-piece into smaller crystal aggregates. As, however, these remain even after a considerable extension of the test-piece very nearly in the same position, the test-piece can still be macroscopically considered as being a single crystal. A Laue photograph was taken of a test-piece at the very edge where the specimen was broken. The pattern which resulted showed the existence of relatively large crystals near the edge. It is clear from this that the metal crystal exhibits great resistance to destruction by mechanical stress.

It is well known that when a metal is distorted in tension it breaks by shear stress, and that this is at a maximum at 45° to the long axis of the test-piece. Supposing that aluminium were a stronger metal and that it were possible to break it by shear stress on one plane, and supposing that we could find a single crystal test-piece the plane of slip of which was oriented at 45° to the longer axis, we should expect the fractured surface to be not a wedge but a plane surface inclined at 45° to the test-piece. Since we cannot do this with aluminium, owing to its weakness, it seemed interesting to discover whether it could not be hardened by the addition of alloying element which does not destroy its crystal symmetry, and that it might thus be made to have the property of slipping only on one plane before it fractured. Miss Elam succeeded in doing this by dissolving 18·6 per cent of zinc in aluminium, and this, in spite of the fact that the lattice of zinc is not face-centred cubic but close-packed hexagonal. This is a one-phase alloy. It was converted into a single

FIG. 8.—Fracture of single-crystal test-piece of aluminium-zinc alloy. The fracture has occurred almost wholly on one principal cleavage plane though there are signs of fracture on a second plane at 90° to it. Both planes make angles of 45° with the axis of the test-piece.

(Reproduced by courtesy of the Institute of Metals.)

crystal test-piece by the method of critical straining and heat-treatment and was then tested in tension. It pulled out almost entirely on one principal cleavage plane, although there were signs of a second plane on which slipping had occurred at approximately 90° to it. Both planes made angles of approximately 45° with the axis of the test-piece (Fig. 8). It is clear, therefore, that fracture did occur on the plane of maximum shear, which is in strict accordance with theory. So far as I am aware, this is the first time that it has been possible to test this.

Taylor and Farren, in a paper on the distortion of aluminium crystals under compression,[24] have found that this is of the same nature as that which occurs in tension. It is due to slip parallel to a certain crystal plane and in a certain crystallographic direction, and the choice of which of

twelve possible crystallographically similar types of slipping actually occurs, depends only on the components of shear stress in the material and not at all on whether the stress normal to the slipping planes is a pressure or a tension.

Single Crystals of Iron.

The study of the distortion of single crystals of iron has yielded results of quite remarkable interest. The lattice structure of this metal is different from that of aluminium. It is body-centred cubic, that is, there is an atom at each corner of the cube and one in the centre. The planes having the largest number of atoms and the largest distance between neighbouring planes are not the same as in the face-centred cubic lattice. For this reason alone, therefore, it was important to study the distortion of the single iron crystal. But there was a further reason. The slip bands of the majority of metals formed in plastic deformation are straight, whereas those of iron are nearly always curved. Nearly all previous workers in this subject have assumed that the iron crystal has a plane of slipping which is a crystal plane, and they have attempted to correlate the slip lines with the traces of crystal planes. These attempts have not met with success, but the work of Osmond and Cartaud [25] constitutes a notable exception. They pointed out that the slip lines which occur when an iron crystal is strained are curved, and they could find no relationship between these either as a whole or in their detail and the crystallographic planes.

Taylor and Elam studied the distortion in tension of single iron crystals prepared by Edwards and Pfeil.[26] They concluded that when an iron crystal is distorted in tension it does not slip along a crystallographic plane, but that the particles of metal "stick together along a certain crystallographic direction and the resulting distortion may be likened to that of a large bundle of rods which slide on one another. The rods stick together in groups or smaller bundles of irregular cross sections and the slip lines which appear upon the polished surface are the traces of these bundles on that surface." This conclusion has been tested by Gough, who subjected a single crystal of iron to alternating torsional stresses. The specimen was ultimately fractured by fatigue, precautions being taken to prevent the development of fatigue cracks to any great extent. Careful microscopical examination showed that the slip bands differed entirely in appearance at different portions of the specimen, but all bands could be described as belonging to one of the following types: (1) One set of straight parallel bands; (2) two sets of bands of differing slopes, those of each set appearing to be straight or nearly so; and (3) distinctly 'wavy' slip bands having a well-defined average slope and limits of slope but impossible to resolve into combinations of straight slip bands.

Gough's analysis led him to the conclusion that alpha iron does slip on crystal planes, but that instead of it always taking place along planes of one type, it may take place on any of the (112), (110), or (123) planes. It is only under very special conditions that any one of the planes will coincide with the plane on which the value of the shear stress resolved in the octahedral direction is the maximum. In general, therefore, slip will occur on two sets of planes simultaneously. It is this which gives rise to the generally curved nature of the slip bands and the very complicated arrangement of which the duplex and 'wavy' bands are types. This is the view of the distortion of the single iron crystal which is now generally accepted. The character of the slip accounts for a property of iron of the highest importance, namely, its tendency to break with a fibrous fracture.

Magnetic Characteristics.

Plasticity is only one of the properties of metals. It is the one of greatest importance to engineers and metallurgists, but from the general point of view of physics all properties are important. Physicists have recognised in single crystals a new approach to many of their problems, and each year this form of metal is being used to an increasing extent as a means of obtaining data on some of the fundamental phenomena of matter. Magnetic, electrical, thermal, and optical properties have been measured for crystals of many metals and of different orientations, and it is only possible to mention a small proportion of this work.

Investigations of the magnetic properties of single crystals of iron have been carried out by Honda, Kaya, and Mashiyama.[27] They prepared single crystals of iron wire 68·1 mm. × 2·4 mm. × 1·81 mm. by the method of critical straining and heating. They found that the hysteresis loss of a single crystal of iron is only one-tenth of that of ordinary transformer iron, and that it increases rapidly with increase in the number of crystals in unit volume. The initial and maximum permeabilities of iron were found to decrease with the number of crystals in unit volume.

A set of five crystal rods, of which three had their axes approximately lying in the (100) plane, and two in the (110) plane, was prepared. The magnetic expansion of these rods was measured, and the following observations were made: (1) The magnetic expansion of single crystals of iron is generally very large as compared with that of ordinary iron. (2) The magnetic expansion in the direction of the tetragonal axis is always positive, whereas in that of the trigonal axis it is always negative. (3) The magnetic expansion curves for crystals of intermediate orientations are determined by the resultant of the above expansion and contraction. (4) The magnetic expansion in ordinary polycrystalline iron is a differential effect of the expansions and contractions of the numerous crystals of random orientations. The work of these Japanese investigators has therefore demonstrated that hysteresis loss and permeability are functions of the number of crystals in unit volume, and that magnetic expansion is a directional property of the crystals.

A similar research was carried out by Gerlach.[28] The results obtained were in substantial agreement with those of Honda and his co-workers, and the magnetic properties of single crystals were shown to be definitely directional. It was found that the initial permeability is greater in the tetragonal than in the digonal direction, and that saturation in the tetragonal direction occurs at a lower magnetic force than in the digonal direction. This investigator found that slight deformation produces considerable changes in magnetic properties, and attributed the small discrepancies between his results and Honda's to the existence in the latter of slight mechanical disturbances. The effect of these was most marked in the curves connecting field intensity and intensity of magnetisation.

The longitudinal magneto-resistance effect in single crystals of iron has been investigated by Webster.[29] He measured the change of resistance in a longitudinal magnetic field for three different orientations of iron crystals. He found that for the tetragonal direction there is no change in resistance in a longitudinal magnetic field, whereas in the trigonal and digonal directions the electrical resistance begins to alter when a magnetic intensity of about 800 c.g.s. units is attained.

Various magnetic properties of nickel crystals have also been determined, principally by Kaya. This investigator found that up to an intensity of magnetisation of 205 c.g.s. units, nickel crystals are isotropic, but that above this intensity the magnetisation varies for different directions of the applied field. Trigonal, digonal, and tetragonal axes are in decreasing order of magnetisability, which is the reverse of the order found for iron. The same investigator measured the change in electrical resistance of single nickel crystals in longitudinal and transverse magnetic field. In a longitudinal magnetic field, every direction of the axes shows an increase in resistance, the amount of increase being in the decreasing order [111], [110], and [100]. These results differ from those obtained by Webster, who found no increase in resistance for the [100] direction in iron crystals.

The magnetic expansion of single crystals of nickel has been measured by Masiyama. He found that in a longitudinal field the magnetic expansion is always negative for all fields and in all directions, and that the absolute amount of contraction decreases in the order of the direction [100], [110], [111]. The transverse effect was found to be the opposite of the longitudinal.

Electrical Conductivity.

A considerable amount of work has been done on the electrical conductivity of single crystals, and in general it has been found that for those belonging to the cubic system the resistivity is the same in all directions, while for those in other systems the greatest resistivity is found to be in the direction of the planes on which slip most easily occurs.

In comparing the difference between single crystal and polycrystalline bars of zinc with respect to thermal and electrical conductivity over the range $-250°$ C. to $+100°$ C., Lewis and Bidwell found that: (1) The thermal conductivity decreases smoothly, but not linearly with rise in temperature. (2) Single crystals of zinc, measured in the direction of the basal plane, have 11-18 per cent better thermal conductivity at 0° C. than polycrystalline bars. (3) Single crystals of zinc have 20-30 per cent less electrical conductivity at 0° C. than polycrystalline bars.

Bridgman has conducted numerous investigations on the conductivity and thermal electromotive force of crystals of low symmetry. In 1926 he published a paper on the thermal conductivity and thermal e.m.f.[30] of single crystals of zinc, bismuth, cadmium, and tin. Both properties were shown to vary with the orientation of the crystals, and this variation was particularly marked in the case of the thermal e.m.f. Using improved methods of casting single crystals which permitted the production of a wide range of

orientations and a more accurate means of measuring the thermal e.m.f. and resistance, he was able in 1928 [31] to demonstrate more clearly the relation between these properties and the orientations of the crystals. He found that the thermal e.m.f. was a linear function of $\cos^2$, where θ is the angle between the axis of the crystal and the length of the rod. This verifies the relation of Kelvin and Voigt, about which Bridgman, on the basis of his previous work, had expressed doubt.

Density.

It has been found that the density of iron single crystals is 0·037 per cent greater than that of the polycrystalline material; that that of nickel single crystals is 0·110 per cent greater than that of the polycrystalline material; and that the density of aluminium single crystals is 0·034 per cent greater than that of the polycrystalline materials.[32]

Electromotive Characteristics.

Measurements of the electrode potential of single crystals of zinc have been carried out at Yenching University, Peking, by Paul A. Anderson.[33] The results indicate that the primary cleavage plane of zinc—the basal pinacoid—yields constant and reproducible values of the electrode potential, and that this value is the same as that obtained from electrolytically deposited crystal conglomerates. This result seems to indicate that in the electrolytically deposited conglomerate the crystals have a random orientation, and that the basal pinacoid plane has the maximum electrode potential of all planes. Attempts to prepare zinc crystals with naturally developed secondary faces proved unsuccessful, and measurements of electrode potential were made on artifically prepared surfaces. The results obtained in this way indicated a qualitatively regular decrease of potential with increase in the angle between the plane under consideration and the primary cleavage plane.

An investigation of the relation between electrode potential and the density of the atom on different planes of zinc crystals has also been carried out in the University of Latvia.[34] The results obtained in this investigation did not agree with those already mentioned, and no difference could be found in the potentials of different, artificially prepared planes.

It is very probable that the electromotive characteristics of a metal vary with the orientation of the surface on which they are measured, but the variation in these characteristics is difficult to measure on artificially prepared surfaces. The Latvian investigators attributed the negative results obtained to this fact. They pointed out that polishing, filing, or rubbing with emery disintegrates the crystallographic planes and the resulting structure is indefinite and shows no differences of potential, whereas etching with dilute acids attacks the surface very unevenly, and no definite plane results. It is probable that the results obtained by Anderson were qualitatively correct, but definite confirmation of these must await measurements of the electrode potential of naturally developed faces.

It is clear from the foregoing results, and others which it has not been possible to include, that both the mechanical and physical properties of the single metal crystal are, in the majority of cases, directional. This fact is more strikingly illustrated in the mechanical tests because the single crystal test-pieces undergo distortion and assume new and striking forms. In both categories, however, the properties of the single crystal differ from those of the crystal aggregate, depending upon its particular orientation. Single crystal alloys have been investigated to a less extent, but in so far as evidence is available, it indicates that the same holds for them. The scientific investigation of metals in the future will have to take into account both the monocrystalline and the polycrystalline states, and the variations in any particular property which may be secured by varying the orientation of the crystal. This will involve the controlled production of single crystals in particular orientations, a field of investigation which is only just being opened up.

Knowledge of the mechanics and physics of the metal crystal is only in its infancy. From the point of view of pure science, it is the single metal crystal which will have to be investigated in the first instance. That of the crystal aggregate of any particular average size should follow at a later stage. Such knowledge will form the basis of the scientific manufacture of metals and alloys possessing properties which can be specified with accuracy and certainty.

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came in from outside. Kolhörster himself had computed $\mu = 0{\cdot}55$ as reported in Meyer and von Schweidler's book, p. 606. Bowen and I had at that time no other observations to guide us, nor did any more appear for more than a year thereafter. Since all conceivable sources of error would make our results come out too high, the fact that our balloons came down with a discharge of approximately one-fourth the expected value was definite unambiguous proof to us that a radiation of such a coefficient as we had assumed in our computations did not come in from outside, that rather, if the observed effects were due to extra-terrestrial rays at all, these rays had to be very much harder than had been supposed, and we so reported at the meeting of the National Academy of Sciences held in Washington in April 1922. In doing so, we did not reflect in any way upon our predecessors. We obviously had no choice but to report our findings. Indeed, we had so much confidence in Hess and Kolhörster as observers that we felt that the very large discrepancy between their results up to 9 km. and ours up to 15·5 km. cast so serious doubts upon the adequacy of hypothesis No. 1 that we spent a year preparing new experiments on absorption coefficients of the penetrating rays to enable us to differentiate sharply between hypothesis No. 1 and hypothesis No. 2, since No. 3 had already been definitely eliminated by Gockel's experiments, now checked by Hess, Kolhörster, and ourselves.

It was eighteen months later, after Dr. Otis and I had made our absorption experiments with lead and water on top of Pike's Peak, that we found that these discrepancies between Bowen and Millikan's and Hess and Kolhörster's balloon findings, discrepancies which had caused us so much concern and raised so much doubt about the interpretation of the penetrating rays, had been removed by Dr. Kolhörster's 1923 work in the Alps, which yielded $\mu/P = 0{\cdot}25$ per metre of water, a result which is in substantial agreement with our sounding balloon data, as we have definitely shown.[22] The difference in the ionisation to be expected at the top of the atmosphere between $\mu = 0{\cdot}25$ and $\mu = 0{\cdot}57$ is enormous, and the sounding balloon flights were the first to reveal the untenableness of the last figure. I believe that all recent work is in substantial agreement with the first figure. We have never thought it necessary to contradict or to answer at all the critiques of our sounding balloon experiments, for the simple reason that the data obtained in these balloon flights appear to speak for themselves since the result yielded is now generally accepted.

Our critics charge Dr. Cameron and myself with misrepresentation because we said that "up to this time the increasing rate of discharge was the sole phenomena upon which the hypothesis of rays of cosmic origin rested", *but they insert the year* 1925 *instead of the correct year*, 1922, and then quote Kolhörster's 1923 data to show our error. The table given in Meyer and v. Schweidler's "Radioactivitat" (1927), p. 606, actually records no absorption coefficient obtained up to 1922 in any way except from measurements in air.

The only remaining point of criticism of our article is in our statement that our observations at great depths in the water of high-altitude snow-fed lakes, definitely shown by long tests to be free from radioactive impurities, represent the first time that the zero of an electroscope had been definitely determined. Our critics think that Bergwitz succeeded in doing the same thing when he in 1915 took an unsealed electroscope into a salt mine and *assumed* the non-existence of any radiations from radioactive impurities in the surroundings. For the purpose of assuredly eliminating completely both local and cosmic radiations, it scarcely seems to us that Bergwitz's procedure in 1915 can be called a trustworthy determination of the zero of an electroscope. In an instrument of a litre capacity containing air at atmospheric pressure, his reading was 8 ions at the surface, 4 ions in the salt mine. With an instrument of the same volume and pressure our reading at the surface is 7 ions, under 150 feet of water it is 1·6 ions. The larger difference in our case probably means that we are better screened from local effects. In any case, unless careful tests for such screening were made, we doubt if Dr. Bergwitz himself would call it a zero determination. However, we are very glad to be informed of his experiments, which we had in fact overlooked.

The worst case of misunderstanding and misstatement that I have seen, however, is met with, not in connexion with articles on cosmic rays, though probably due to misconceptions engendered by these articles, but in a review of a short article I wrote by request for the American Philosophical Society on "The Last Fifteen Years of Physics"[5] which is abstracted in the *Physikalische Berichte*, April, vol. 8, p. 465, No. 7; 1927. In so short a review as I had to give here of so huge a field, it is of course impossible that any two people would select precisely the same group of advances to emphasise, but if there was any national bias in the list selected I was completely unconscious of it. Furthermore, such bias was not noticed by the best informed European physicist of my acquaintance, who actually viséd this particular article before it went to press. The reviewer's misunderstanding and misrepresentation of the article is presumably due to preceding misconceptions, and barely possibly in part to the fact that in this necessarily very sketchy enumeration of a number of important advances, I repeatedly inserted references to my book on "The Electron" or to my more extended articles like those on cosmic rays, merely for the sake of giving the reader opportunity to look up, if he wished, my more complete discussion of the advances under consideration. The reviewer appears to have taken these references, without looking them up, as claims of discovery by me, whereas they actually contain merely the history of the advances, altogether objectively presented. *Actually no such claims as the reviewer asserts are either made or implied.* Again, therefore, I beg the reader to read the article in question before he draws any conclusion about it.

Returning to the main question here under discussion, there can be no doubt whatever about the fact that every country tends to get its own contributions out of their true perspective. Having been brought up, scientifically, largely on German books, I well recall my surprise, when I had opportunity to spend a few months of study in Paris and Cambridge, to find how badly I had underrated French and English contributions to the development of physics, an error which a few months of study in these centres was well calculated in its turn to correct. It is in this correcting of perspective that the great value of foreign study lies.

We Americans have in the past made so few contributions ourselves, and have been brought up so completely on foreign books, and in foreign schools, that we have been in a particularly favoured position for appraising the contributions of other countries, without being too much impressed with our own scientific importance, since everybody has recognised the fact that we had none. That we, too, are beginning to be charged with a nationalistic bias in science is perhaps merely an indication that some contributions are actually beginning to come from this side of the water.

As international contacts in science increase, and they are now doing so more rapidly than ever before, it is not too much to expect that science will very soon become more completely objective that it has been heretofore. There will be two signs of the approach of that hoped-for day: first, a decreasing amount of international claiming of priorities; secondly, and even more important, a decreasing amount of suspicion of nationalistic motives and of making of unwarranted charges of prejudice in the presentation of work.

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The Welland Ship Canal.

THE opening on July 1 of the reconstructed Welland Ship Canal between Lake Erie and Lake Ontario marks an important stage in the developments of the North American waterways which will ultimately enable large vessels to pass between the Great Lakes and the Atlantic Ocean. Lakes Superior, Michigan, Huron, Erie, and Ontario constitute the greatest lake system in the world, and owing to their geographical position and the rapid exploitation of the vast natural resources of the North American continent, the traffic on them, already of enormous proportions, is steadily increasing. Ore, coal, and grain form the greater part of the cargoes carried, and the vessels employed are especially constructed for the quick stowage and discharge of cargo. Many of them, too, are of very large dimensions, there being more than 300 vessels of 600 feet or more in length. In 1926 one vessel carried a single cargo of 15,900 tons, while 12,000 tons of ore have been loaded in about a quarter of an hour. Owing to climatic conditions traffic is only possible for seven or eight months in the year, but in this time a greater tonnage passes between Lake Superior and Lake Huron than passes through the Suez Canal, the Panama Canal, and the Manchester Ship Canal combined.

Between Lake Superior and the Atlantic, however, there are three natural barriers to shipping, the first between Lake Superior and Lake Huron which has led to the building of great locks on both the Canadian and United States sides; the second between Lake Erie and Lake Ontario, formed by the Niagara escarpment across which the Welland Canal runs, while the third lies in the unnavigable stretches of the St. Lawrence below Lake Ontario, to avoid which the St. Lawrence Canal was constructed. This canal at present only admits of the passage of vessels about 260 ft. in length, but its enlargement is already being discussed. One interesting feature of the traffic through the canals is that ships, whether Canadian or American, pass through free of tolls.

The Welland Canal is situated a few miles to the west of the River Niagara and runs practically north and south from Port Weller on Lake Ontario to Port Colborne on Lake Erie, the distance being about 25 miles. Between the lakes there is a difference of level of 325 ft. The first Welland Canal was built a hundred years ago with forty small wooden locks admitting the passage of vessels of 7½ ft. draught. In the 'forties of last century the canal was reconstructed with twenty-seven locks 120 ft. long, 26 ft. wide, and 8½ ft. of water. It was again reconstructed in the 'seventies with locks 270 ft. in length, 45 ft. beam, and 14 ft. of water, and the traffic by 1904 had grown to 620,000 tons and by 1914 to 4,000,000 tons per annum. By then the decision to convert it into a ship canal of the first order had already been made, and the canal to-day has but eight locks, but these are each 820 ft. in length, 80 ft. wide, and with 30 ft. of water over the sills.

Needless to say, the present reconstruction of the canal has involved engineering works of the first magnitude. Embankments, breakwaters, harbours, storage basins, spillways, weirs, bridges have all had to be built, while the most important

feature of the canal is the flight of three twin locks, Nos. 4, 5, 6, which have been built at Thorold and constitute a structure 4100 ft. in length and more than 300 ft. wide. The three locks together have a total lift of 139½ ft., being 54½ ft. greater than the lift of the three locks at Gatun on the Panama Canal. The locks are not so large as those in the Panama Canal, which are 1000 ft. long and 110 ft. wide, but the lift for such a work is unprecedented. The walls for the greater part are formed of reinforced concrete monoliths 60 ft. in length.

During the past year a fully illustrated account of the canal and its construction has been published in *Engineering*, and the articles have included descriptions of the great excavating machines, the travelling forms and the concreting plants with the aid of which the massive walls have been built. In the Panama Canal ships are towed through by electric locomotives, but in the Welland Canal they will proceed under their own power. Every precaution, however, has been taken against accident; the twin locks have double gates, and wire rope hawsers guard the entrances to the locks. The gates themselves are 82 ft. high, 48 ft. wide, and 5 ft. thick, each weighing 480 tons. For the control of the gates and the working of the numerous large sluices and valves throughout the system, electrical machinery has been installed and current for this will next year be available from a power station placed at the foot of the three twin locks. This will contain three 5000 h.p. hydraulic turbines working under a head of 186 feet. The whole of this great work has been carried out by various contractors working under the direction of the Department of Railways and Canals of the Dominion with Mr. Alex. J. Grant as Engineer-in-Charge.

News and Views.

THE discourse by Sir Harold Carpenter which we publish to-day as a special supplement provides a very complete survey of the important results which have been obtained by the study of single crystals of metals. Whilst ordinary metals consist of a large number of crystals with their axes directed more or less at random, means have been devised for producing specimens, large enough for the tests usually applied by the engineer to metallic specimens, but consisting of a single individual. An extensive field has thus been opened up for the study of the properties of solids. The use of single crystals eliminates one very obscure factor, the existence of boundaries of unknown properties between the crystals, and also, by limiting the directions in which slip can occur under the influence of stress, greatly simplifies the geometrical conditions of a mechanical test. The study of the electrical, and especially of the magnetic, properties is correspondingly simplified. It becomes possible to compare the properties of metals with those of ionic crystals, such as rock salt, which have so far proved most amenable to theoretical treatment. The work on metallic single crystals is thus certain to throw much light on a problem of the greatest interest to the engineer as well as to the physicist—that of the cohesion of solids.

THE methods adopted by the crystallographer for growing perfect crystals of salts fail completely when applied to metals, and it has been necessary to devise new methods. For readily fusible metals, the slow solidification of the molten metal in a tube cooled from one end has proved most successful, but other means of attaining the same end have proved their value. The production of very large crystals in homogeneous metals by suitable annealing after critical strain, due originally to Sir Harold Carpenter and extensively applied, especially by him and Miss Elam, has furnished the material for the detailed study of the deformation of single crystals, in which the X-ray method of examination has rendered such valuable services. Lastly, the ingenious method of the Dutch investigators, depending on the decomposition of the vapours of metallic iodides by heat, has made available crystals of some of the most refractory of the metals. There still remain many unsolved problems, and there is still no general agreement as to the nature of the process of hardening by cold-working, but Sir Harold Carpenter clearly indicates the immense advances in the study of metals made possible by the new technique.

THE Institute of Physics a short time ago appointed a committee to inquire into the possibility of drawing up a catalogue of apparatus which had been used in the course of investigations leading to important discoveries. At the request of the committee the Institute is now making a general appeal to all who have charge of historic apparatus. The appeal, which is signed by Dr. W. H. Eccles, Sir F. W. Dyson, Sir W. H. Bragg, Sir C. A. Parsons, Sir J. J. Thomson, Sir R. T. Glazebrook, and Sir H. G. Lyons, is made with the object of obtaining information as to the existence of apparatus and the researches it was used in, so that students of the history of science may be able to visit, identify, and study it. It is also suggested that the committee could possibly assist the owners, if they so desire, to place the apparatus where it could be permanently secured to the nation. In such institutions as the Science Museum, the Conservatoire des Arts et Métiers, the Deutsches Museum, and the Smithsonian Institution, England, France, Germany, and America already possess extensive collections of great value, and there are probably few observatories, laboratories, or scientific societies which do not own some historic apparatus, while other instruments are in private hands. Practically every private collection, however, is ultimately dispersed, and the compilation of such a catalogue as that now being formed might lead to the more historic apparatus becoming the nation's property. As with pictures and other works of art, the selective principle should be applied, and a

joint committee of the Institute of Physics and kindred societies would be a suitable body to act in an advisory capacity.

IN the past, wars, riots, and fires have been the cause of the destruction of much valuable apparatus. Gilbert's collection, which he bequeathed to the Royal College of Physicians, was lost in the Great Fire of London: Hevelius lost both observatory and instruments by a fire at Danzig in 1679; the great fire at Copenhagen in 1728 led to the destruction of Römer's telescopes, and the first observatory at St. Petersburg was burnt down in 1747. One of the most deplorable of all losses was occasioned by the fire at the Volta Centenary Exhibition at Como in 1900, when Volta's original piles and cells, etc., were lost. Wars have been no less destructive than fires. The manuscripts of Thomas Harriott, astronomer and mathematician, disappeared during the Civil War; Gregory Saint-Vincent, the seventeenth century geometer, lost all in the siege of Prague; Chladni lost some of his acoustical apparatus during the Napoleonic Wars, while Regnault, after the occupation of Paris by the Germans, returned to his laboratory at Sèvres to find his standard apparatus and the results of his great researches on the expansion of gases ruined. The destruction of Priestley's library and apparatus occurred during the Birmingham Riots of 1791. How important instruments may disappear unrecorded is shown by the case of Sturgeon's electrical apparatus. In 1825 the Royal Society of Arts recorded the award of a medal and thirty guineas to Sturgeon for the gift of his electromagnetic apparatus, but this, including the first electromagnet ever made, has unfortunately long since disappeared. Such, it may be hoped, will not happen to any important collection in the future, and we feel that the Institute of Physics is doing a public service in obtaining records which should go far to prevent such losses from happening.

ON June 14 a large meeting of university professors, academicians, and scientific men met in the great hall of the Palace of the Apostolic Chancery in Rome in commemoration of the third centenary of the death of Prince Federico Cesi, the founder of the Accademia dei Lincei. After introductory remarks by the president, Prof. Giuseppe Gianfranceschi, Prof. Antonino Anila recounted how the idea came to Cesi of bringing together all scholars of that time—the first serious attempt to organise human knowledge recorded in history. This academic activity was to have its centre in Rome, but was to embrace the whole world then known. From this suggestion was born the Accademia dei Lincei, so named from the power attributed to the lynx (*la lince*) of seeing into the depths of things. The most illustrious scientific men of the day supported the project, and Galileo was desirous of becoming a member of the Academy. Prof. Anila emphasised the fact that, so far as his astronomical discoveries went, Galileo received nothing but help from the Church, the opposition to him being based on his persistence in his own special interpretation of the scriptures. Cesi himself made a large number of discoveries bearing on the structure, functions, and classification of plants, being the first to utilise the microscope in such investigations; and in addition he made noteworthy contributions to mineralogical and zoological knowledge. Prof. Anila was followed by the Rev. Prof. Agostino Gemelli, who traced the developments taking place after the death of Cesi, and indicated the relationships between the original academy and the Accademia Pontificia dei Nuovi Lincei and the Reale Accademia dei Lincei of the present day. Prof. Gemelli also contested the view, expressed by certain historians, that the activities of the academy were often restricted as the result of clerical antagonism, especially that of the Jesuits, or of lack of papal support.

THE appointment of a Committee to consider and report on the training of candidates and probationers for appointment as forest officers in the government service was announced in NATURE of June 21. In directing attention to this Committee, the Secretary of State for the Colonies points out that the proper conservation and development of the forests of the British Empire is a problem which has been attracting increasing interest of recent years and is one of great national importance. The Colonial Office is responsible for the management of about one-third of the total forest area of the Empire. It is recognised that the Colonial Forestry Services have been very weak in numbers, whilst, owing to changes or possible changes in the demands for different kinds of timber, it is becoming a matter of urgent importance to explore the possibilities of making fuller uses of the tropical hardwood forests of the Empire. It is considered that a careful inquiry may show that there are some directions in which greater facilities may be made available for the training of future forest officers. To undertake such an inquiry is the *raison d'être* for the appointment of the Committee.

JOHANN KEPLER is recognised as one of the founders of modern astronomy, and his discoveries are known to every student of physical science. He was to Germany what Galileo was to Italy and Newton to England, and it is therefore with interest we learn that arrangements are being made to commemorate the tercentenary of his death, which falls on Nov. 15 of this year. Kepler died in 1630, in the midst of the Thirty Years' War, and was buried in the churchyard at Ratisbon, but the churchyard was practically destroyed in the desperate struggles of the time and the site of his grave is no longer known. In 1803, however, the venerable Prince Primate Dalberg, known for his love of the fine arts, erected a cenotaph at Ratisbon to Kepler's memory, and the commemoration proceedings will commence on Sept. 24 before this memorial with an address by Dr. von Dyck, of the Munich Technical High School. The same evening a meeting of the Society of History and the Society of Natural History will be held, and on the following day Prof. Bauschinger of Leipzig will deliver an address in the old Reichssaal at Ratisbon. The proceedings will be brought to a close with an act of homage before the bust of Kepler in the Walhalla near the city.

MANY places in Germany beside Ratisbon are connected with the memory of Kepler. Born in the little town of Weilderstadt in Würtemberg, Kepler

attended school at Maulbronn, was a student at the University of Tübingen, and in 1594 became a professor of astronomy at Gratz. At Prague he lived for a short time with Tycho Brahe, and he afterwards held professorships at Linz, Rostock, and at Sagan in Silesia. There was nothing in his upbringing or surroundings to stimulate Kepler's interest in science and from his earliest days he had a struggle against misfortune. A sickly child of well-born but indigent parents, he suffered more than once from severe illness, he had the unhappy experience of seeing his parents separate, while after his own marriage, domestic affliction and pecuniary difficulties dogged his footsteps. Even after receiving the appointment of imperial mathematician to the Emperor Rudolph, his salary was often sadly in arrears, and it was while attempting to obtain some money that he died at Ratisbon. Yet amid all his difficulties he was able to publish no fewer than thirty separate works, and he left behind twenty-two volumes of manuscripts. It was apparently from the lectures of Moestlin that he learnt of the revolutionary views of Copernicus, while it was from the long series of observations of Tycho Brahe that he obtained the material which enabled him to search out and enunciate the laws of planetary motion. Beside the memorial at Ratisbon, there is a monument to Kepler at Weilderstadt, a description of which was given in NATURE of July 21, 1870, at the time it was unveiled.

AN industry—the breeding of game birds—which is well established in Great Britain, though on a small scale, is attracting greater attention in the United States of America. Already some of the largest and most productive game farms in the world have been developed there, and the supply is met by an ever-increasing demand. This has largely to do with the development of the sport of shooting in the States, for most of the game-birds and their eggs are used for restocking State game departments and the 'shootings' of sportsmen's clubs. But in addition the demand for stock for propagating, and the needs of bird fanciers and zoological gardens, are so great that it is seldom necessary to dispose of the birds for food. For the guidance of game-bird breeders the U.S. Department of Agriculture has issued two *Farmers' Bulletins* (Nos. 1612 and 1613) on the propagation of aquatic game birds and of upland game birds, from which may be obtained concise and useful hints on the most up-to-date methods employed in the industry.

THAT alligators should have an economic importance so great as to merit the establishment of alligator reserves and farms will surprise many readers, but it is perhaps more astonishing to learn that the use of alligator hides for one purpose or another has been in vogue in the United States since about 1800. Nowadays the industry concerns itself with the manufacture of trunks, travelling bags, purses, pocket-books, shoes, and miscellaneous novelties, and the result has been a decline in the numbers of alligators which, in some places, threatens extinction. In the beginning of this century the output of the United States tanneries was about 280,000 skins annually, valued at 420,000 dollars, but during the past few years the number cannot have exceeded 50,000 a year, prices ranging from 35 cents for a 3-foot skin to 3 or 4 dollars for a 7-foot skin. Accordingly, the alligator, once denounced, has come to be protected by local laws which enforce a close season, a licence for trappers, and have even created a State Alligator Reservation in Florida. This and much information about the habits, the hunting, and the food of *Alligator mississipiensis* is contained in *Technical Bulletin*, No. 147, of the U.S. Department of Agriculture.

THE fundamental scientific research work which is being carried out under the Clothworkers' Research Scheme in the University of Leeds is year by year becoming more important and receiving more extensive recognition. Perhaps no better indication of the value which is being placed upon this work in scientific circles could be given than that accorded by the Royal Society, which has recently made a grant of £200 for apparatus to facilitate the X-ray work on textile fibres upon which Mr. W. T. Astbury is engaged. This work, along with the physico-chemical work under Mr. J. B. Speakman, is gradually clearing up the complex problem of the structure of the wool fibre, and in the near future it is probable that, knowing what wool really is, better control of the manufacturing processes may be ensured. Thus, the wisdom of running, side by side, fundamental scientific research and textile technology is becoming more and more justified.

THE Department of Zoology of the British Museum (Natural History) has received from Col. F. Wall a collection of more than a thousand skulls and skeletal preparations of Indian snakes, which is by far the most complete collection of its kind ever assembled. The Department of Geology has acquired by purchase a skeleton of the short-legged rhinoceros *Teleoceras fossiger* from the Pliocene of Kansas, U.S.A. An important addition to the collection of meteorites is a fine mass of meteoric iron weighing 299 lb. and forming a complete individual mass, from South-West Africa. This was one of some thirty masses weighing about ten tons displayed in the Public Garden at Windhoek. These had been collected from the desert in the neighbourhood of Gibeon in Great Namaqualand, where in prehistoric times there must have been a terrific shower of enormous masses of iron. Another valuable donation to the Department of Mineralogy is a magnificent group of large crystals of melanterite (iron vitriol) found in ancient workings in the Skouriotissa mine, Cyprus. Mr. R. Crawshay has presented to the Department of Botany 167 crayon drawings of *Russula*. *Russula* is a genus of Agaricaceae (toadstools) which is characterised by the bright colours of its cap and the clearly cut, paper-like gills. Mr. Crawshay has just published a book, "Spore Ornamentation of the Russulas", in which a classification of the species on the basis of the spore characters has been fully worked out. In this work it was impossible to publish drawings of the fungi which were examined, and consequently the original drawings have an additional value.

As a memorial to the late Sir George Beilby, the distinguished chemical engineer, who died in 1924, a

fund was collected in 1926 from the interest on which, at the discretion of the administrators, awards are to be made from time to time to British investigators in science, to mark appreciation of distinguished original work carried out over a number of years, preference being given to investigations relating to the special interests of Sir George Beilby, including problems connected with fuel economy, chemical engineering, and metallurgy. The administrators of the fund have announced the award of £250 each to Dr. Guy D. Bengough, of the Chemical Research Laboratory, Teddington, and Mr. Ulick R. Evans, of Cambridge. The administrators of the fund are the presidents, treasurers, and secretaries of the Institute of Chemistry, the Society of Chemical Industry, and the Institute of Metals.

THE thirty-ninth annual report of the Council of The Institution of Mining and Metallurgy records the following awards which were presented at the annual general meeting on June 26. The gold medal of the Institution to Sir Thomas H. Holland, in recognition of his distinguished services to geological science and to the mineral industries during his tenure of high public appointments—notably those of director of the Geological Survey of India and of rector of the Imperial College of Science and Technology—and of his researches and publications upon the mineral resources of the British Empire and their relationship and national and international problems. 'The Consolidated Gold Fields of South Africa, Ltd.' premium of forty guineas to J. B. Richardson, for his paper on "The Importance of Recovered or 'Secondary' Tin". The 'William Frecheville' Student's Prize of ten guineas to A. Bray, for his "Notes on the Banket Reefs of the Gold Coast Colony". The 'Arthur S. Dwight' post-graduate travelling grant of two hundred guineas to W. D. Jones. In accordance with the conditions of the grant, Mr. Jones proceeded to the United States in October, where he spent about three months in the study of metallurgical plants and in making personal contacts with operating men. Since his return to England he has submitted to the Council an exhaustive report of his visit. A special grant of £50 from the 'Post-Graduate Grants Fund' of the Institution to S. R. B. Cooke, to enable him to proceed to British Columbia to gain practical experience. The grant was made on the nomination of Prof. James Park, dean of the faculty of mining and economic geology of the University of Otago, New Zealand.

THE University of Freiburg has conferred the honorary degree of doctor of natural philosophy upon Dr. F. W. Aston in recognition of his work on isotopes and other subjects.

AN interesting innovation has been introduced into the advance proofs of papers recently circulated by the Physical Society. Wherever a mathematical symbol occurs for the first time, or is defined, the symbol is noted in the margin. Thus any reader who wishes to find quickly what the symbol denotes has only to run his eye up the margin, a far more rapid process than is sometimes necessary in scientific papers.

A PROVISIONAL programme of the fourth World's Poultry Congress, to be held at the Crystal Palace on July 22–30, has just been issued. The congress is being organised by the Ministry of Agriculture and Fisheries, in conjunction with the Department of Agriculture for Scotland and the Ministry of Agriculture for Northern Ireland, and fifty-six countries, ranging alphabetically from Argentina to Yugo-Slavia, are taking part in it. The programme contains a short account of the objects of the congress, a list, with many photographs, of the personnel of the national committees, and a diary of the daily sessions. The papers to be read at the morning meetings are extraordinarily numerous and comprehensive, but the provision of many afternoon and evening entertainments and a post-congress tour suggest that there is no danger of making Jack and Jill dull children. The fee for full membership of the congress is £2:2s. for each member from the United Kingdom, and half that amount for wives and relatives of members.

A CORRESPONDENT directs our attention to an experiment described in a recently published school book on chemistry, in which metallic mercury is to be heated in a crucible. This would have the effect of volatilising the mercury, and if the experiment were performed by a number of pupils in a school laboratory the effects might be very serious. Teachers are reminded that the poisonous effects of mercury vapour were recently emphasised by Prof. Stock, and they are warned that such experments as that just described should never be carried out in school laboratories.

MESSRS. H. K. Lewis and Co., Ltd., 136 Gower Street, W.C.1, have just issued a handy list of current works on engineering—electrical, civil, and mechanical—which many readers should find serviceable.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:—A director of education for the County Borough of Middlesbrough—The Town Clerk, Municipal Buildings, Middlesbrough (July 8). An assistant lecturer in agricultural engineering in the University of Leeds—The Registrar, The University, Leeds (July 12). An assistant instructor in dairying at the British Dairy Institute—The Secretary, British Dairy Institute, The University, Reading (July 12). An agricultural education officer under the Isle of Wight County Council Education Committee—The Director of Education, County Hall, Newport, I.W. (July 14). A bacteriologist at the Government Lymph Establishment, Hendon—The Director of Establishments, Ministry of Health, Whitehall, S.W.1 (July 14). An assistant lecturer in geography in the University of Leeds—The Registrar, The University, Leeds (July 14). An assistant lecturer in organic chemistry at the University College of North Wales, Bangor—The Registrar, University College of North Wales, Bangor

(July 14). Temporary assistant chemists in the Government Laboratory—The Government Chemist, Clement's Inn Passage, W.C.2 (July 19). An assistant works manager of the Metal and Steel Factory, Ishapore, India—The Secretary, Military Department, India Office, S.W.1 (July 19). Three research fellows in the Department of Glass Technology of the University of Sheffield—The Registrar, The University, Sheffield (July 19). An assistant plant pathologist under the Department of Agriculture and Forests of the Sudan Government—The Controller, Sudan Government London Office, Wellington House, Buckingham Gate, S.W.1 (July 21). An inspector of agriculture under the Department of Agriculture and Forests, Sudan Government—The Controller, Sudan Government London Office, Wellington House, Buckingham Gate, S.W.1 (July 21). An assistant lecturer in the Department of Zoology of King's College, London—The Secretary, King's College, Strand, W.C.2 (July 21). A research physicist in the Department of Glass Technology of the University of Sheffield—The Registrar, The University, Sheffield (July 21). A lecturer in botany and assistant lecturers in pharmacy and chemistry at Robert Gordon's Colleges, Aberdeen—The Secretary and Registrar, Robert Gordon's Colleges, Aberdeen (July 23). A research demonstrator in the division of biochemistry of the London School of Hygiene and Tropical Medicine—The Secretary, London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1 (July 24). A student probationer (zoologist, botanist, or physiologist) at the Marine Biological Laboratory, Plymouth—The Director, Marine Biological Laboratory, Plymouth (July 30). A professor of education in the Rhodes University College, University of South Africa—The Secretary, Office of the High Commissioner for the Union of South Africa, Trafalgar Square, W.C.2 (July 31). An assistant professor of anatomy in the University of Manitoba—The Dean of the Faculty of Medicine, Medical College, Winnipeg, Canada (Aug. 8). A woman demonstrator and assistant lecturer in chemistry at Royal Holloway College—The Principal, Royal Holloway College, Englefield Green, Surrey (Aug. 30). A Smartt memorial scholar in the University of Cape Town, for research in subjects bearing upon agriculture—The High Commissioner for the Union of South Africa, Trafalgar Square, W.C.2 (Sept. 30). A principal of the Aston Technical College—The Chief Education Officer, Education Office, Margaret Street, Birmingham (Sept. 30). Assistant lecturers and advisers in, respectively, agriculture, dairy husbandry, and horticulture, under the Bucks Agricultural Committee—The Agricultural Organiser, County Offices, Aylesbury A lecturer in agricultural bacteriology in the University of Reading—The Registrar, The University, Reading.

ERRATUM.—June 28, vol. 125, page 967, col. 2, line 5 from end, for W. E. Beaton read W. E. Benton.

Our Astronomical Column.

Comets.—Prof. H. E. Wood has computed the following parabolic orbit for Forbes's comet, 1930*e*:

T	1930 May 10·588 U.T.	
ω	321° 8′	1930·0
Ω	278 13	
i	97 15	
log q	0·06183	

The following orbit of comet 1930*d* is by Dr. A. C. D. Crommelin from observations on May 2, 12, 22 (*B.A.A. Circ.* 95); it represents an observation of June 3 within a few seconds of arc:

T	1930 June 14·1826 U.T.	
ω	192° 18′ 18·92″	1930·0
Ω	76 47 11·54	
i	17 24 34·76	
ϕ	42 21 25·37	
log a	0·4913883	
log q	0·0049406	
Period	5·458614 years.	

Mr. Blathwayte, of Johannesburg, who had not heard of the discovery of the comet, picked it up as a new comet on June 3; it is the second time that he has taken a known comet for a new one; he has also discovered two comets that were really new. Comet *d* is now too far south for European observers, but may be followed in the southern hemisphere for some time; it approached the earth within 4 million miles early in June; this seems to be the third closest approach on record. No news is yet to hand of meteors associated with the comet having been seen.

The Planet Pluto.—Diligent search of old plates at Mount Wilson observatory has revealed four images that undoubtedly belong to Pluto on plates taken in December 1919 (*U.A.I. Circ.* No. 289). As they are situated within some 6 minutes of arc of positions calculated with the aid of the Uccle observation of January 1927, and as the mean daily motion (−5·14$^{sec.}$ in R.A. +6·8″ in decl.) is also in close accord with that calculated, the identity of the Uccle image with Pluto is also confirmed. The mean of the four positions was telegraphed as follows:

U.T. 1919.	R.A.	N.Decl. 1930·0.	Mag.
Dec. 29·0667	6^h 29^m 3·8^s	19° 21′ 56″	19

There is probably some error in the telegraphed magnitude: it would be expected to be about 16.

U.A.I. Circ. 289 gives the following orbit of Pluto calculated by Nicholson and Mayall from observations in 1919 and 1930 (the 1927 position was not used).

T	1988 June 5·5 U.T.	
ω	111° 46′	1930·0.
Ω	109 22	
i	17 9	
log a	1·60071.	
Period	251·80 years.	
e	0·2575.	

The perihelion distance is 29·61, which is slightly inside the orbit of Neptune. Owing to the high inclination, the two orbits do not approach each other within some four units. It will now be possible to make a trustworthy ephemeris of Pluto back to the beginning of the century, so that any other images that may be present on old plates should be identified with tolerable ease.

Research Items.

The Mound Builders of the Central Southern United States.—Mr. Warren K. Moorehead communicated to the Congress on Mid-Western Archæology held at St. Louis in 1929 a brief study of the mound-culture of the Mississippi Valley which has now been published in *Bull. 74 of the National Research Council of Washington*. Within the area of some twenty States several mound-building cultures are to be distinguished. The general custom of mound-building extends between the great plains and the Hudson. In a territory of 600 to 800 miles in extent mound art is highly developed, especially in certain places. An attempt to arrange the various mound cultures according to their status in cultural development suggests the following order—the Hopewell culture of the lower Scioto Valley, the Etowah culture of Northern Georgia and the Tennessee-Cumberland valleys, "Fort Ancient", the average village population of the Kanawha, Illinois, Arkansas, Wabash, Savannah, and other valleys, the Central Illinois Valley culture, and the Florida-South Georgia culture. As regards the origins of the Hopewell culture, it is suggested that a band of very early Algonkin reached or originated in eastern Iowa, one branch may have passed up into Wisconsin, the other proceeded eastward through Illinois and Indiana to Central Ohio, building mounds as they went. On reaching the Scioto Valley they became sedentary and attained the culmination of the Hopewell development. As regards the ultimate origin it is to be noted that Mrs. Nuttal has found seven detailed comparisons between early Toltec art and the Etowah culture.

Pleistocene Man in Ireland.—Important work of excavation carried out by members of the Spelæological Society of the University of Bristol in caves in the South of Ireland is recorded in the *Proceedings* of the Society for the year 1929. The excavations, which were carried out in the summer of 1928, resulted in a discovery of no little importance for the history of early man in Ireland. They were undertaken with the view of obtaining material for comparison with results obtained by the Society in the Mendip caves—Aveline's Hole and others. Several caves in the neighbourhood of Dungarvan, Co. Waterford, were examined; but in one only, that of Kilgrany, was it found that any results were likely to be obtained. The area in which the caves are situated lies beyond that covered by the southern Irish moraine and was therefore uncovered in late Pleistocene times, when Ireland was probably joined to Britain. Excavation was carried to a depth of twelve feet from the original surface of the cave. In a stratification of several horizons, hearths were discovered in the second and fourth strata, and beneath the latter was stalagmite which showed an unbroken surface. Beneath a tufaceous portion of the stalagmite was a third hearth associated with a late Pleistocene fauna. In removing the tufaceous portion human remains were brought to light, which careful clearing revealed had been placed in a kneeling position with the left side resting against the wall of the cave. The body had then been surrounded and covered with stones which kept it in a kneeling and upright position. Prof. Fawcett, who has made a careful examination of the bones, pronounces them to be those of a male, 4 feet 7 inches in height. The skull is long, low, and with a pentagonal appearance from behind, recalling one of the Cro-Magnon features. On the whole, it is of Mediterranean type. Although no artefacts were found which would indicate a cultural horizon, there can be no question that the remains are the first of Pleiocene man to be discovered in Ireland.

Fungus Spores in Urine in Disease.—Some phenomena discussed in a paper by Toshio Ohue in the *Science Reports of the Tohoku Imperial University*, Sendai, Vol. 5, No. 1, as to the association of a fungus with a case of meningitis, are distinctly puzzling and deserve fuller elucidation. The spores of the fungus were found in the urine and cerebrospinal fluid of the patient; they were grown on in pure culture and the fungus is identified provisionally as *Alternaria tenuis* Nees. The fungus was also isolated from the dried persimmons which had been eaten by the patient a short time before his sudden illness. When cultures of this fungus were fed to animals it proved pathogenic to a marked degree to guinea-pigs, rabbits, and albino-rats, though in these animals the lungs are the organ chiefly affected, whilst in man the brain was attacked, the lungs showing little alteration. Comparison of the toxic action of cultures with spores and of ultra-filtrates of the bouillon cultures of the fungus suggested that the pathogenicity of the fungus is due primarily to the large spores (7-35 μ long by 7-12 μ broad). The mechanism by which the spores found their way to the urine is still in need of elucidation.

Iron Bacteria.—A very thorough study of these specialised micro-organisms appears to have been made by I. Turowska at various Polish stations, and is reported upon in the *Bulletin International de l'Académie Polonaise*, Cl. des Sc. Math. et Nat. No. 8-10, B.1, pp. 255-282, 1929. Organisms of the genera *Leptothrix*, *Gallionella*, and *Sideromonas* are studied. They require a certain amount of iron in the water, but more in sunlight, because the iron then tends to be precipitated more readily, less when the *p*H is near neutrality than at *p*H 6 for the same reason. Also, in saline waters they do not develop even when the iron content of the water is considerable, presumably because of the reaction of other salts present with the iron. The author attributes to the absence of solar radiation the frequent development of the iron bacteria in pipes even when the iron content of the water supply is low.

The Identification of Hair.—In an article entitled "Circumstantial Evidence from Hairs and Fibres" in the issue of *Chemistry and Industry* for May 30, Dr. C. Ainsworth Mitchell discusses the question of the identification of human hair and the hair of various animals, as well as the fibres of fabrics, from the point of view of legal evidence. The article contains many points of general biological interest as well as information of legal interest.

Inheritance in Fowls.—Frizzled fowls were known in Italy so early as the year 1600. They apparently came from the East, and in the eighteenth century were cited as occurring domesticated in southern Asia and the Philippines, Mauritius, and Mozambique. The feathers curl backwards; the barbs are also curled and later wear off, leaving the feather bare. Probably the skin was originally black. Mr. F. B. Hutt has made an investigation (*Jour. Genetics*, vol. 22, No. 1) of the current belief that frizzle fowls do not breed true and that the homozygous condition is lethal. His results show that the case is parallel to that of the blue Andalusians. Homozygous birds are viable, but they show the frizzled condition of the feathers in a more extreme form than the heterozygotes. The latter are preferred in the fancy, and so only such birds are usually found. When crossed with normally feathered fowls they gave a 1 : 1 ratio of normals and heterozygous frizzled. From this and other

evidence it is shown that the frizzled character is conditioned by a single non-sex-linked Mendelian factor, which is dominant, as are so many other factors in domestic breeds of fowls. In the same number Messrs. L. C. Dunn and Walter Landauer have shown from crosses of silky and white Leghorn fowls that the genes for dominant white, cerebral hernia and polyldactyly are located in the same linkage group or chromosome, the two former very near together and polydactyly some distance away, since it shows loose linkage with the other two.

Sardine Fishing in California.—Mr. W. L. Scofield, of the Bureau of Commercial Fisheries, gives a detailed account of the methods used in the sardine fishery in "Sardine Fishing Methods at Monterey, California" (Division of Fish and Game of California. *Fish Bulletin* No. 19. Contribution No. 84 from the California State Fisheries Laboratory, March 1929.) The California Sardine *Sardinia cærulea* is very important commercially, occurring in shoals in enormous numbers. Great skill is needed in picking out those of the right size and much depends on the judgment of the captains of the boats. The schools are located by the luminescence produced by their movements. This can be seen readily on a dark night, and therefore the fishing is almost entirely confined to the night hours when the moon is not shining. A description of the Monterey fishery is given which can be used as a basis for judging future changes in the conduct of the industry. This includes fishing gear, fishing methods, notes on markets and canneries, besides general knowledge of the fishing-grounds. The bulletin is illustrated freely with diagrams and photographs, and embraces a large amount of useful information.

Copepods and Mites from the Philippines.—Copepods from Central Luzon described by P. A. Chappuis (Harpacticids), Friedrich Kiefer (Calanoids and Cyclopoids), and Hydracarina by C. Walter, include new species and sub-species (*Philippine Journal of Science*, February 1930). They are of interest because their region is almost unworked for these groups. Among the Harpacticoida new sub-species of *Nitocra platypus* and *Canthocamptus bidens* are recorded and a new species of *Diaptomus*, *D. sensibilis*. In the Cyclopoida a new variety or sub-species of *Mesocyclops leuckarti* was very abundant and also *Mesocyclops hyalinus*; a form belonging to the *Cyclops varicans* group was also present. All these are widely distributed species. Three mites are described, two of which are new species, *Limneria bakeri* and *Neumania flagellata*, whilst the third, represented by one ovigerous female, belongs to the Sumatran species *Neumania ambigua* Piersig.

Insects of Samoa and of South America.—Two publications of the British Museum (Natural History), more especially of interest to entomologists, have recently come to hand. Both are continuations of monographs which have already been alluded to on several occasions in our columns. The "Insects of Samoa" receives further contributions from Mr. J. R. Malloch, of the U.S. Bureau of Biological Survey, which form Part 6, Fasc. 5 of that publication. They deal with the Dipterous families Ortalidæ and Calliphoridæ. The "Diptera of Patagonia and South Chile" has reached Part 5, Fasc. 1, which is devoted to a description of flies of the family Dolichopodidæ from that region. Its author, Mr. M. C. Van Duzee, of Buffalo, U.S.A., describes a number of new genera and species of the family concerning which practically nothing was previously known from this part of South America. The two publications bear the date 1930 and, like all which emanate from the British Museum, are well printed and clearly illustrated.

Physiological Studies of the Swede.—Numerous studies of the sugar content of such 'root' crops as swedes, mangels, and beet have suggested that the sugar content is by no means uniformly distributed throughout the swollen storage organ. Mr. J. Caldwell has now carried the problem a stage farther in that, by numerous measurements and some simple experiments, he has shown that the increase in girth of the storage organ is different in north, south, east, and west directions, and that this different increase is closely correlated with the activity of the leaves above (*Proceedings Roy. Soc. of Edinburgh*, **50**, 130-141; 1929–30). Mr. Caldwell concludes, mainly as the result of observations of plants upon which all leaves on one quadrant of the shoot are removed, that this correlation is explained by the movement of food downwards into the swollen axis from the leaves above. It is desirable, however, to bear in mind the earlier observations of Jost which have shown the dependence of radial growth in the axis upon leaf development above, quite irrespective, apparently, of whether the leaf was sending food supplies downwards into a storage organ.

Anatomy of Grass Roots.—Dr. M. Henrici has some very interesting notes on this subject in *Science Bulletin*, No. 85, of the Department of Agriculture, South Africa, 1929. In the course of investigations near Vryburg, in British Bechuanaland, and in Ermelo in the eastern Transvaal, he had occasion to study the anatomy of a number of the native grass roots. He found these to fall into two types, one thin and fibrous and branched, the other more swollen, with a looser cortex and less branched. The same types of roots have been described by Brenchley and Jackson at Rothamsted and by other workers, but Henrici's observations, in a new area, are very extensive and seem to add some new facts. He points out that the fatter and less sclerenchymatous type of root may turn up upon the same plant that previously formed the fibrous roots and that its formation was associated with the annual rains. He describes the thickening of the cortex by tangential divisions in the layers lying just outside the endodermis, and adds the interesting note that in some roots in successive seasons there may be successive bursts of this growth activity. In the outer cortex, these roots develop large intercellular spaces traversed by radial plates of tissue; Henrici points out that whilst this structure might have value as a type of aerenchyma, under South African conditions such an adaptation often had little significance; on the other hand, he notes that roots of this type of organisation seem to retain water better when, as so frequently happens, the soil is dry over long periods.

Factors Favouring Fruit Production.—Whilst the necessity of intermingling varieties if a good crop is to be obtained in an orchard mainly planted with a self-sterile variety forms the main theme of *Bulletin* 497 (December 1929) of the Cornell University Agricultural Experimental Station, written by L. H. MacDaniels and A. J. Heinicke, the pamphlet is a very interesting example of how scientific and comprehensive the American experiment station worker can venture to make an exposition of a practical problem in horticulture. The main facts as to pollination and fertilisation of flowers are simply explained and then the results are given of various pollination experiments between different varieties of fruit, most of the work being done with apple. These experiments seem to show that under the New York conditions the Delicious apple is one of the best pollinisers, and Baldwin, with pollen of poor germinating quality, one of the least satisfactory. The discussion

of this special problem is then followed by a comparison of fruit-bearing on spurs and upon long shoots, and with an indication of the influence of the water supply at different seasons upon the processes of flower-bud formation and of flower and fruit development. The *Bulletin* is very effectively illustrated and seems a very good example of the way in which an experiment station may make the significance of its labours intelligible to the horticultural public it tries to serve. V. R. Gardner discusses some similar problems in Special *Bulletin* No. 195 (March 1930) of the Agricultural Experiment Station of the Michigan State College upon "maintaining the productivity of cherry trees". This pamphlet will interest some horticulturalists because of its close scrutiny of the value of the practice of pruning, or otherwise treating the trees, so as to obtain most of the fruit upon spurs. Whilst this practice may be justified in Madison because the spur buds are hardier, under Michigan conditions it would seem that it can easily be carried too far and militate against the general growth and total yield of the trees.

Carboniferous Fossils of Tibet.—The late Sir Henry Hayden collected fossils from the west and north-west of Lhasa where no geological observations had previously been made. These have been described by Dr. F. R. C. Reed (*Palæont. Indica*, N.S., **16**, 1930) and comprise Foraminifera, corals, brachiopods, polyzoa, and mollusca. The brachiopods are almost without exception known from the Upper Carboniferous of the Urals or from parts of Asia, and the prevalence of the foraminifer *Schwagerina princeps* suggests that the age is Uralian.

Anatomy of *Mysorella Costigera*.—The example set by the Zoological Survey of India of small monographs on the fresh-water gastropod mollusca of India as a basis for the accurate determination of those species, if any, that act as the intermediate hosts of internal parasites inimical to man, has borne fruit in the production of a paper on the anatomy of *Mysorella costigera* Kuster (*Records Indian Mus.*, vol. 32). The author, R. V. Seshaiya, of the Merchant's High School, Tirupati, gives a very full and careful description of this small hydrobiid mollusc, its habits and anatomy, with abundant illustrations, that cannot fail to be of great use to future workers in the same field, but abstains from drawing any general conclusions to which his researches may have led him.

Superconductivity in Compounds.—The property possessed by some substances of losing all electrical resistance at very low temperature, which, until Prof. W. Meissner discovered it in copper sulphide, was known to occur only with metals, has now been observed by him and H. Franz in some other compounds (*Die Naturwissenschaften*, May 9, p. 418). The new superconductors are titanium nitride, vanadium nitride, the carbides of molybdenum, niobium, and tantalum, and probably also titanium carbide. The nitrides become superconductors at about 1·2° Abs., molybdenum carbide at about 7°, tantalum carbide at 9°, and niobium carbide at 10°. Some oxides were also examined, but none was found to be superconducting. Niobium carbide exhibits the phenomenon at a higher temperature than any other known substance, the nearest to it being Rose's alloy of lead, tin, and bismuth, which was found by Prof. McLennan to have a transition temperature of 8·5° (see NATURE, vol. 125, p. 447; 1930).

Photo-Conductance in Silver Halides.—An attempt to arrive at the mechanism of formation of the latent photographic image is described by F. C. Toy and G. B. Harrison in two papers in the June number of the *Proceedings of the Royal Society*, on photo-conductance phenomena in silver halides. Some silver bromide was set up in an apparatus in which the changes of its electrical conductivity which occur on exposure to light could be studied at short intervals after illumination started. So long as no permanent decomposition was permitted to take place, it was found that the photo-current (an *internal* current through the crystals) started to flow practically at the instant of illumination, and rose to a constant final value, proportional to the intensity of the light, within a few hundredths of a second. This conductivity had the metallic property of increasing with a decrease in temperature below −150° C., whereas the current flowing in the dark, which is probably due to an electrolytic movement of silver ions, fell off as the temperature was diminished. The photo-current can thus be reasonably ascribed to electrons. The view taken by these investigators is that when silver bromide is exposed to light, some bromine ions are changed to neutral atoms by the photoelectric process, and are then able to react with neighbouring molecules, such as those of gelatin, leaving the silver atoms with which they were originally paired effectively free.

Electrical Transmission of Pictures.—There are many honoured customs in Japan the origins of which are lost in the mists of antiquity. None is considered of greater importance by the people than the series of impressive ceremonies marking the accession to the throne of a new Emperor. In a paper read to the World Engineering Congress at Tokyo on Oct. 31, 1929, and published in *Electrical Communication* for April last, Y. Niwa describes a new system for the electrical transmission of pictures. This system was used to inform the Japanese of the progress of the Coronation ceremonies in November 1928. During the twenty-two days which elapsed between the Emperor's departure for Kyoto and his return to Tokyo, the number of pictures transmitted by the Niwa system between Tokyo and Osaka, a distance of 236 miles, amounted to two hundred and fifty-three. The bulk of these pictures were reproduced in the newspapers. As an example of the rapidity of the transmission the following example is given. As the imperial procession and the imperial carriage were moving across the Double Bridge at Tokyo at 7.10 A.M., they were photographed. At 8 o'clock, less than an hour later, the pictures were received in Osaka. At 9.30 A.M. they were published in a four-page supplement of the *Osaka Daily News* (*Mainichi Shimbun*). As in most of the other picture transmission systems at present in use, the picture to be transmitted and the receiving film are wrapped respectively around drums which are made to rotate synchronously and at the same time are pushed forward in an axial direction. At the transmitting end a toothed rotating disc is used to interrupt the light emanating from a source. The pulsating light produced is projected on the picture and reflected to a photo-electric cell, and the electric currents are conveyed by overhead lines and telephone cables to the receiving end. The signals can also be transmitted by radio.

Solubility of Gold in Mercury.—Accounts in the literature on the solubility of gold in mercury are misleading, and it has even been stated that "gold is miscible with mercury in all proportions". In a paper in the May number of the *Journal of the American Chemical Society*, Sunier and White show that the solubility is quite small, about 0·1306 atomic per cent at 20°, or 100 lb. of mercury dissolve about 2 ounces of gold. The amalgamation process for the extraction of gold really depends on surface adhesion.

Agricultural Meteorology.*

THE meeting of the Commission of Agricultural Meteorology of the International Meteorological Organisation at Copenhagen immediately after the Agricultural Section of the Conference of Empire Meteorologists in London testifies to the interest now being taken in that subject.

The problems of agricultural meteorology would seem capable of division into two broad classes, macrocosmic and microcosmic. In the first, we study the influence of weather on crop yields on a large scale, seeking to fill in the general lines of a broad picture by studying recorded crop and weather data over as many years as possible and using statistical methods to determine their interrelations. In the second, the physiological reactions of the plant to the principal weather factors in plant growth—light, heat, and moisture—are considered in detail by a careful study of particular phenomena in plant growth under the completely controlled conditions of the laboratory or in a small-scale field experiment where as many conditions are controlled as possible.

The macrocosmic problem is the especial province of the statistician, and since the pioneer work of Hooker many studies have been published all over the world on the correlation of weather and crops. One might instance the work of Moore, Bradford Smith, and Kincer in America, the very fine work of Wallèn, the president of the Copenhagen Conference in Sweden, and Fisher's work in Great Britain, which has effected a very great improvement in the statistical technique employed, by enabling us to relate crop yields to a continuous sequence of weather instead of merely to weather at isolated periods. The importance of this in crop-forecasting is very great.

Important as the distinction is between the two methods of approach, however, they must not be regarded as being entirely unrelated. Valuable as it is to know the degree to which crop yields depend on particular meteorological variates such as rainfall or sunshine, we cannot use our knowledge to the greatest advantage without knowing the reasons for these relations, and these can only be discovered by the microcosmic method.

The position is being rapidly reached to-day in which the statistician who has discovered the existence of interrelations by the large-scale method is also consulted on the planning of detailed experiments by which the reason for these relations may be discovered. For example, under the "Agricultural Meteorological Scheme" of the Ministry of Agriculture, "Precision Record" experiments on wheat are being conducted at several centres on two varieties of wheat. Great care has been taken to use the modern principles of randomisation and replication to ensure valid results, and each time a set of observations is taken, 256 randomly chosen ¼ metre lengths, 128 of each variety, are examined, and measurements of shoot height and counts of leaf number, shoot number, and number of emerged ears are made. In a word, accurate measurements of growth are being obtained, and it is hoped that when the data have been continued over a sufficient number of years, some of the known relations between wheat yields and weather may become explicable in terms of the previous growth of the plant. It is to be hoped that these methods will be greatly extended in the future.

While meteorological data have usually been considered accurate enough for the large-scale correlation of weather and crops, there is an influential body of opinion which considers that the meteorological data at present collected are inadequate for the intensive and detailed study of weather effects on growth phenomena. Thus at the London Conference we find one delegate (Lawrence Balls) saying, "The meteorology recorded in the field crop, that which the plants themselves are experiencing, is not that recorded in the screen. In Egypt at night you can get as much as 5° C. lower temperature, lasting for perhaps only a few minutes, among the plants, than in the neighbouring screen. Then again the question of soil temperature is important. The temperature of the soil in fallow land is very considerably higher than the temperature of soil under the crop." Another delegate (Walter) said: "In the case of wind the effect on plant growth is evidently a function, not only of the age of the plant, but of the duration of high velocities and the change of direction during the period of specified wind velocities. None of these factors is made available for the research worker in the records of the various observatories as usually published."

Again, at Copenhagen we find Angström saying, "Measurements of temperature in the lowest layers of the air, in conjunction with the meteorologico-agricultural problems, ought, it would seem, to be primarily directed towards making clear the connexion between the nature and the quality of the vegetation on the one hand, and the distribution of the temperature in the lower layers of the air on the other". M. Angström then goes on to outline the instrumental technique necessary for this purpose. Much the same view is expressed by M. W. Schmidt: "Although plant growth depends so much on weather, there nevertheless exists to-day a huge hiatus between what the agriculturist needs and what the meteorology and climatology provide. . . . Special methods are necessary for this purpose, which relate to the whole life-environment of the plant, that is, the lowest layers of the air and the uppermost layers of the ground—fine measurements which demand a special apparatus." We find other delegates at Copenhagen expressing the same opinion.

Another point of great interest which was discussed both in London and at Copenhagen was Sir Napier Shaw's proposal that the week should be used as a time unit in meteorology. This resulted in a resolution at the London Conference that "In the opinion of the Conference the month is too long a period for the purpose of summarising, for publication, statistics of agricultural meteorology, and the Conference recommends that the week be adopted for the purpose". The Copenhagen Conference was a little more non-committal: "La Commission attire l'attention des météorologistes sur la proposition de Sir Napier Shaw et recommande d'éprouver dans certaines recherches, la valeur d'emploi de la semaine comme unité climatologique, de manière à reconnaître par l'expérience si l'emploi généralisé de cette unité est convenable".

It is probably true that while the week is a great improvement on the month, there will always be purposes for which individual research workers will require the original observations taken at daily or, it may be, more frequent intervals.

It is not possible in a short article to deal exhaustively with the whole proceedings of the Copenhagen Conference, but one should not conclude without mentioning Holdefleiss's résumé of the work done in Germany on the correlation of crop yields and weather, which seems to follow on the same lines as similar work already done in England and America, and Åkerman's account of what appears to be the very fine work at Svalöf on the study of the relative resistance to frost of different varieties of wheat, a combination of field experiments and of laboratory work in which plants are subjected to cold artificially produced.

J. O. IRWIN.

* Commission de Météorologie Agricole. Procès-Verbaux de la 3ème Réunion, Copenhagen, 1929.

Mutations Induced by X-Rays.

THE effects of X-rays and radium in producing mutations in various economic plants are being studied at the University of Missouri by Dr. L. J. Stadler and others. A general account of this work appears in the *Journal of Heredity* for January last. Dormant and germinating seeds of barley were treated in this way, and the self-fertilised progeny grown separately from the seeds of each head or tiller of a treated plant. Usually only a single culm from each plant has been affected in the primordial stage. Its seeds produce progeny which segregate, thus revealing the recessive character produced by the mutation resulting from X-ray bombardment.

Among 2800 progenies from treated plants, 53 mutations were found, 48 of which were recognisable as seedlings, while 1500 controls produced no mutations. Later, among 20,000 head progenies of treated barley, some 250 mutations were found. These were mainly chlorophyll abnormalities. About 60 per cent of the latter were white, 5 per cent virescent white, and 15 per cent yellow of various shades. They are mostly lethal, and probably represent mutations at many different *loci* in the chromosomes. A few other mutations, such as pale green, non-glaucous or winter barley habit, were found in progenies grown to maturity.

In all these cases, the mutation apparently consists in a change of a dominant (normal) gene to a recessive one in a somatic cell of the embryo or young seedling. In contrast to the frequency of induced mutation in barley, which is diploid ($2n = 14$), they were rare in similar experiments with wheat and oats. This is probably because the latter are hexaploid and the mutations would therefore probably be masked by the normal genes contained in the duplicate pairs of similar chromosomes.

The same method applied to maize produced similar results. Since a single cell of the embryo mutates, a mutation affecting either the tassel or the ear results in the production of heterozygous plants in the second generation, and segregation only in the third. When young growing embryos which are heterozygous are irradiated, the resulting plant may be a chimæra. A plant heterozygous for purple plant colour may have a sector of green tissue. Treatment applied even on the sixth day after pollination may produce chimæras, but from treatment on the first or second day there result plants entirely recessive for a character heterozygous in the seed.

It was found that dormant seeds would withstand a dose fifteen to twenty times heavier than germinating seeds, and that the resulting mutation rate was roughly proportional to the strength of dosage. Storing irradiated seeds for two weeks before planting did not affect the percentage of mutations. Germinating seeds irradiated at temperatures of 10°, 20°, 30°, 40°, and 50° C. also showed no significant difference in mutation rate.

In maize, endosperm chimæras or mosaics were produced, which Emerson has shown are due to chromosome disturbance, that is, to the loss of a chromosome or a portion of one. These losses can be detected when the dominant gene is derived from the male nucleus, for its loss will reveal in the cell the presence of the recessive gene represented in both female nuclei of the triple fusion from which the endosperm is formed.

Maize has ten pairs of chromosomes, and the loss of seven of them can be identified in endosperm mosaics by the genes which they carry. Certain chromosomes or genes appear to be lost much more readily than others. When maize seeds are treated on the day after fertilisation, numerous small mosaic spots appear showing the recessive characters. If the treatment is applied on the fifth day, the spots are so small that the seeds appear stippled and their nature can only be examined with a magnifier. Such treatment also produces chromosome irregularities in the young embryo. The resulting plants may (1) be defective, (2) have 50 per cent defective pollen, (3) show recessive characters for which the treated seeds were heterozygous.

The method is also being applied to the production of bud mutations in the apple. As apple trees are highly heterozygous hybrids in which breeding results are very slow, it appears probable that the application of the method to fruit trees may be of more economic importance than it is in the case of cereals, where natural mutation has already produced great numbers of types for selection and crossing.

R. RUGGLES GATES.

University and Educational Intelligence.

CAMBRIDGE. — Frank Smart prizes have been awarded to E. W. Jones, Jesus College, in botany, and to W. J. Hensman, Trinity Hall, in zoology.

In connexion with the International Botanical Congress, which is to be held in Cambridge in August next, it has been decided to confer honorary degrees on the following: John-Isaac Briquet, director of the Conservatory and Botanic Garden, Geneva; Pierre Augustin Clément Dangeard, professor of botany at the Sorbonne; Friedrich Ludwig Emil Diels, professor at the University of Berlin and director-general of the Botanic Garden and Museum at Berlin-Dahlem; Thore Gustaf Halle, professor and keeper of the Palæo-botanical Department of the Swedish State Museum of Natural History, Stockholm; Lewis Ralph Jones, professor of plant pathology at the University of Wisconsin; Carl Joseph Schröter, emeritus professor of botany at the Technical University of Zurich; Friedrich August Ferdinand Christian Went, professor of botany and director of the Botanic Garden and Laboratory of the University of Utrecht.

EDINBURGH.—The University Court has approved of the institution of a post-graduate diploma in German. It has also agreed to institute a diploma in tropical veterinary medicine. The course for this diploma, which will be held partly at the University and partly at the Royal (Dick) Veterinary College, will occupy six months (October to March) and will commence this year. The curriculum will include classes in parasitology and entomology, bacteriology, meat and milk production, feeding of animals, breeding of animals, epizootology, and a number of special lectures and demonstrations in subjects of special interest to tropical veterinary surgeons.

LONDON.—Dr. J. Scott Lidgett has been elected vice-chancellor for the year 1930–31 in succession to Sir Gregory Foster, Bart., whose term of office expires on Aug. 31. Mr. J. L. S. Hatton, principal of the East London College, has been appointed deputy vice-chancellor for the same period in succession to Dr. Scott Lidgett.

New professors have been appointed to University chairs as follows: *Bacteriology* (University College Hospital Medical School), Mr. C. Cyril Okell; *Chemistry* (University College), Prof. C. K. Ingold, now Professor of organic chemistry in the University of Leeds; *Geography* (Birkbeck College), Miss E. G. R. Taylor; *Physics* (Imperial College—Royal College of Science), Prof. G. P. Thomson, now professor of natural philosophy in the University of Aberdeen.

Mr. H. R. Hamley has been appointed to the University readership in education tenable at the London Day Training College.

OXFORD.—At the Encænia held on June 25 in the Sheldonian Theatre, the honorary degree of D.C.L. was conferred on Sir Hugh Bell, Bart., and that of D.Sc. on Sir Arthur Keith. In presenting Sir Hugh Bell, the Public Orator, Dr. A. B. Poynton, alluded to his eminence in the coal and iron industries, to the widespread influence exercised by his speeches and letters to the Press, to his unceasing advocacy of the principle of free trade, and to the eminent services rendered to the State by the eloquence, insight, and wisdom of his public utterances. Introducing Sir Arthur Keith, the Orator enlarged upon his skill as a great anatomist in disentangling the relationships of the various species and races of primitive man as disclosed by their osseous relics. The fineness of the transition between different races was illustrated by an apt quotation from the "Metamorphoses" of Ovid. His investigation of origins, said Dr. Poynton, had led Sir Arthur Keith to go further, and to speculate on the destiny and goal of all created things. Would that, casting his gaze both forward and backward, he might announce the speedy return of the Saturnian age.

It had been hoped that another distinguished representative of science, namely, Prof. Einstein, would have been present to receive the Doctor's degree; but much to the regret of the University he was prevented by illness from attending.

In the Creweian Oration which followed the bestowal of the honorary degrees, Dr. Poynton alluded to the gift of the Radcliffe Observatory site by Sir William Morris, and pictured Dr. Radcliffe approving of the supersession of his telescope by the stethoscope, and of the charts of the heavens by the temperature charts of the Infirmary.

WALES.—The Council of the University College of North Wales, Bangor, has appointed Dr. J. L. Simonsen (lately professor of organic chemistry at the Indian Institute of Science, Bangalore) to the chair of chemistry, and Dr. F. W. R. Brambell, lecturer in zoology, King's College, London, to the Lloyd Roberts chair of zoology.

APPLICATIONS are invited by the University of Wales for the following scholarships:—The Cecil Prosser Research Scholarship of the value of £250 for research in the Department of Tuberculosis; the Mrs. John Nixon Scholarship of the value of £150 for research in the Department of Medicine and Medical Pathology; the Lord Merthyr Research Scholarship of the value of £200 for research in the Department of Surgery; and the Ewen Maclean Research Scholarship of the value of £150 for research in the Department of Obstetrics and Gynæcology. Particulars of the award of the scholarships and forms of application may be obtained from the Registrar, University Registry, Cathays Park, Cardiff.

Historic Natural Events.

July 6, 1928. Hailstorm at Potter, Nebraska.—A remarkable hailstorm occurred during which hailstones "as large as grapefruit" fell, one of which measured 17 inches in circumference and weighed 1½ pounds. This appears to be the largest single hailstone of which there is authentic record. The stones could be heard hissing through the air, and when they fell on ploughed or soft ground they completely buried themselves. Very little damage was done by these stones beyond the unroofing of a few houses, as they fell 10-15 feet apart.

July 7, 1558. Hailstorm near Nottingham.—It is recorded that during a "marvellous tempest of thunder" near Nottingham, hailstones fifteen inches in circumference fell.

July 8, 1707. Great Heat.—This day, called for some time after "Hot Tuesday", was so excessively hot and suffocating in England, because of the absence of wind, that several persons died, or were in great danger of death, at their harvest-work. A former servant of the Rev. W. Derham, F.R.S., a healthy, lusty young man, was killed by the heat, and several horses on the road dropped down and died the same day.

July 8, 1893. Thunder and Hail.—During the afternoon very heavy thunderstorms and tremendous hailstorms, accompanied in some cases by whirlwinds, took place in the north of England. The hailstones which fell at Richmond, Yorks, were up to two inches in diameter. Photographs of two groups of these hailstones, some being split to show the characteristic structure, have been reproduced in many text-books of meteorology.

July 8, 1923. Carrbridge Flood.—After a violent storm, nearly 600 yards of permanent way on high embankments were washed away by a flood at Carrbridge, and a stretch of two miles, between Aviemore and Inverness, was so damaged that traffic could not be resumed for a month.

July 11, 1863. Tornado in Russia.—After very hot and gloomy weather, a whirlwind 700 feet wide levelled houses and trees to the ground, and raised the dust in dense conical columns of black smoke. A post, 31 feet high, 9 feet in the ground, 11 inches in diameter at the base, was lifted whole out of the ground, two large stones were carried up from a ravine on to level ground, children were carried through the air, and iron sheets were carried 24 miles. Hailstones four inches in diameter fell.

July 11-12, 1892. Glacier Flood.—The front of the small glacier of Tête Rousse, south-west of Mont Blanc, gave way, releasing a mass of imprisoned water and ice estimated at 200,000 cubic metres. This flood rushed down the steep valley in a great wave, destroying two hamlets and several houses and causing 200 deaths.

July 12, 1900. Ilkley Flood.—Great damage was done by a sudden flood at Ilkley, Yorkshire, between 2 and 3 P.M. Ilkley is built on the slope of Rombald's Moor, which rises steeply to the southward to a height of 1323 feet, and it seems probable that there was a very heavy downpour on the moor immediately above the town, the water running off the entire breadth of the land as off a roof. A workman said that "the clouds seemed to come down until touching the lamp-posts and then poured out solid water". Every road was turned into a watercourse, and torrents swept through the steep streets of the town for several hours, excavating trenches many feet deep. The lower rooms of houses were filled nearly to the ceilings, the furniture being washed into the streets, lamp-posts were snapped across, and several houses collapsed under the weight of water, with loss of life. After the storm had subsided the kitchens were filled with mud, which was banked high outside the vacant squares where the windows had been. From one house thirty tons of boulders and rubbish were removed, and the débris swept by the flood into the River Wharfe formed a great sand-bank. In one part of Ilkley the rainfall was 5·40 in., the greater part of which fell in a single hour.

Societies and Academies.

EDINBURGH.

Royal Society, June 2.—O. F. T. Roberts: On radiative diffusion in the atmosphere: The processes of long-wave low-temperature radiation in the atmosphere have been studied with the view of investigating the extent to which they may be regarded as diffusion-like; the decrease of water-vapour with height is taken to be exponential, that of temperature to be constant up to the tropopause, and then to be zero. Full allowance is made for the radiation being diffuse. The expression for the upward flow of radiation is obtained in the form of a power series in the temperature gradient in the troposphere; the coefficient of the first power of the temperature gradient is defined as the "coefficient of radiative diffusion". There is a certain amount of ambiguity about the coefficient so defined.—**D. Jack:** A simple spectrum comparator. The instrument, which is inexpensive and easily constructed, consists of a microscope with two objectives giving images of two spectrum photographs or other objects in a single eyepiece. The use of a prism silvered for external reflection allows of the photographs being placed side by side on the microscope stage. By this arrangement the length of the objects which the instrument can accommodate is not restricted by the size of the instrument.—**W. O. Kermack, R. H. Slater, and W. T. Spragg:** Certain quinoline and benzacridine derivatives yielding coloured adsorption compounds with iodine. In the case of the active anilinoquinoline compounds the colour is usually developed in presence of solutions containing iodine at a concentration of the order of $N/10{,}000$, whilst in the case of the benzacridine compounds the colour is still apparent at concentrations of $N/100{,}000$ or even less. The effect of variation of concentration of compound iodine and hydrogen ions and other circumstance has been investigated. The chromogenic property appears to depend not on the nitrogen atom in these compounds but on the molecule as a whole. The compounds investigated differ from most of those previously known to give colours with iodine in that they are basic and form colloidal solutions in which the particles are positively charged.—**S. G. Jones:** A study of apothecial development in the leaf-spot disease of red clover. The disease is caused by the fungus *Pseudopeziza Trifolii*. The apothecial fructifications occur singly, but far more frequently in small clusters on both sides of the leaf and at the same spot. Their development is initiated by a small group of vegetative cells accompanied by an "ascogonial coil" and invariably situated within sub-stomatal cavities of the leaf. The ascogonial coil is capable of branching and extending itself into neighbouring stomatal cavities, there to initiate fresh apothecia. The ascogonial coil and its branches, however, prove to be abortive structures, but their proximity to certain cells of the vegetative mycelium is believed to exercise a stimulus, possibly nutritive, causing these cells to become multinucleate. The development of apothecia proceeds in an apogamous manner from these multinucleate cells, termed "primordial cells". They give rise to the ascogenous hyphæ. The terminal cell of a primordial group invariably passes out to the exterior of the leaf at a stomatal pore, pointing to a respiratory function.—**E. L. Ince:** Tables of the elliptic cylinder functions.

CAPE TOWN.

Royal Society of South Africa, Mar. 19.—A. Pijper: The blood-groups of the Bantu.—**F. G. Cawston:** Some observations on the embryonic radula of Limnæidæ. In the embryonic stage it is possible to recognise the marginal teeth with their denticles, the tricuspid laterals and the narrower central tooth of each row. Radulæ are best mounted in glycerine jelly. The number of teeth increases rapidly after the egg hatches, until the mature individual mollusc possesses several thousand teeth.—**R. H. Compton:** The flora of the Whitehall district.—**V. H. Brink:** A comparative study of the sacrum of the Griqua.—**C. Gordon and L. Hogben:** The separate identity of the pressor and pigmentary effector activity of pituitary extracts. When exposed to the action of cold normal sodium hydroxide for two hours, the pressor activity was found to be reduced more than 90 per cent. The pigmentary effector activity increased. The increase was doubtless due to the lack of interference from concomitant vaso-motor phenomena.—**D. Slome and L. Hogben:** Further observations on the relation of the pituitary gland to the chromatic function of *Xenopus Lævis*. The comparison of reactions of totally hypophysectomised and normal toads (*a*) to photic stimuli and (*b*) to the injection of posterior lobe extracts yield data which reinforce the conclusion that the *W*-mechanism of a previous communication can be identified with the anterior lobe of the pituitary gland.—**Enid Hogben:** Some metabolic changes associated with pigmentary effector activity in *Xenopus Lævis*. Eyeless animals have a significantly higher respiratory rate than eyed animals. The effect of removing one or both lobes of the pituitary gland lowers the dermal respiratory rate by about 24 per cent, and the calcium and magnesium content of the serum by about 30 per cent. Significant differences occur between males and females in all cases; males had a higher respiratory rate than females, and the calcium and magnesium content of the serum was lower in males than in females.—**L. Hogben:** Some remarks on the relation of the pituitary gland to ovulation and skin secretion in *Xenopus Lævis*. Autopsy of large females kept for two years after total operative removal of the pituitary revealed the fact that the ovary had undergone almost complete involution in all cases. Implantation of glands from other individuals or injection of anterior lobe extracts induced ovulation.—After removal of the whole pituitary gland or the anterior lobe alone, the copious secretion of slime so characteristic a response of *Xenopus Lævis* ceases entirely. Injections of anterior lobe extract produce within a few hours complete shedding of the skin. The autacoid is heat stable and ether soluble.—**A. Zoond:** (1) The localisation of respiratory exchange in the scorpion. Occlusion of the book lungs of *Opisthophthalmus capensis* with a thin film of rubber solution. Determinations of oxygen caused total inhibition of respiration.—(2) The localisation of respiratory exchange in the polychæte *Bispira Voluticornis*. Cutaneous respiration is 32 per cent of the total, and the branchial filaments are the principal region of respiratory exchange.—**L. P. Bosman and H. Zwarenstein:** The blood-sugar in normal and eyeless *Xenopus Lævis*. Higher in eyeless animals than in normal specimens.—**Sir Thomas Muir:** (1) Note on sums of N-line minors pertaining to an N-by-$N+2$ array. (2) Not on the derivatives of the eliminant of two binary cubics.

ROME.

Royal National Academy of the Lincei, Mar. 2.—A. Angeli: Pyrrole blacks.—**L. Cambi and T. Ricci:** Arylnitrosoferropentacyanides: formation from arylhydroxylamines and nitroprusside. In aqueous alcoholic solution, the reaction between sodium nitroprusside and phenylhydroxylamine yields first the hyponitrosoferrocyanic complex, $[(CN)_5\ FeNO]^{III}$,

which then passes into the aquoferrocyanide $[(CN)_5FeH_2O]^{III}$, which then passes into the aquoferrocyanide $[(CN)_5FeH_2O]^{III}$, and this, under the action of the nitrosobenzene formed in the first phase, is converted into the arylnitrosoferropentacyanide complex $[(CN)_5Fe(NO)C_6H_5]^{III}$.—**B. Segre**: Construction of bisextuples of straight lines.—**Maria d'Ascia**: Test of the method of least squares for the numerical integration of linear differential equations.—**M. Brelot**: Point sources of heat in a radiating plane in thermal equilibrium.—**A. Wintner**: The anharmonic analysis of secular inequalities furnished by Lagrange's approximation.—**A. Belluigi**: The tectonics of certain deep structures discovered gravimetrically in the Paduan plane.—**Stefano Lodovico Straneo**: Moll's vibration galvanometer. Various points connected with the action of the Moll galvanometer are discussed.—**B. Rossi**: A method for the study of the magnetic deviation of penetrating rays.—**E. Bossa**: The Hall effect for the metals, nickel, iron, and copper, in weak magnetic fields. For nickel and iron, the course of the Hall coefficient in weak magnetic fields is substantially different from that in strong fields, the gradual increase observed on diminution of the field becoming rapid at about 30 gauss for nickel and at about 6·2 gauss for iron; this rapid increase is maintained at least so far as 2 gauss and 0·2 gauss for nickel and iron respectively. With both metals, dissymmetry of the galvanometer deviations is noted on inversion of the magnetic field. With copper, on the other hand, no trace of such dissymmetry exists, and the Hall coefficient exhibits only a slight increase as the strength of the magnetic field is lowered to about 1 gauss.—**G. Bargellini** and **A. Grippa**: 2:5-Dibromophenetidine. Bromination of phenacetin with a quantity of bromine corresponding with four atoms per molecule results in the formation of 2:5-dibromophenacetin, which may readily be hydrolysed to 2:5-dibromophenetidine. The results obtained confirm the conclusion previously drawn, that the first halogen atom introduced into the phenacetin molecule enters in the ortho-position to the ethoxy group and the second in the ortho-position to the acetylamino group.—**P. Principi**: Observations on the age of the travertines of Ellera in the neighbourhood of Perugia.—**G. Brunelli**: Eutrophy from stagnation in artificial lakes.—**P. S. Israel**: Investigations on chronaxia. (3) Action of lithium on the chronaxia of the neuromuscular preparation of the frog. Lithium chloride has a distinctly unfavourable action on this phenomenon and cannot replace sodium chloride, this action being exerted particularly on the nerve and to a less extent on the muscle.—**B. Monterosso**: Cirrepedological studies (6). Behaviour of *Chthamalus stellatus* in different experimental conditions.—**M. Curzi**: First observations on the mutation of a hyphomycetes.—**G. Cannicci**: Contribution to the study of glutathione in Teleostei. Observations on the method of determination (1). Of the two methods which have been suggested for the determination of glutathione, the nitroprusside method, especially as modified by Randoin and Fabre, although not absolutely accurate, gives results sufficiently exact for physiological experiments.—**U. Cassinis** and **L. Bracaloni**: Hydremic curves caused by rest and by physical exercise (2).—**S. Visco**: Protein ration and energy ration. When given a diet deficient in protein, rats slowly lose in weight and ultimately die, no matter what the quantity of energy ration consumed. Thus, physiological and economic utilisation of the ternary substances absorbed is possible only to organisms satisfied as regards their protein requirements.—**V. Rivera**: Cosmic waves and cellular multiplication (germinating seeds) (1).

WASHINGTON, D.C.

National Academy of Sciences (*Proc.*, Vol. 16, No. 3, Feb. 15).—**Francis Bitter**: On the diamagnetism of electrons in metals. A formula for diamagnetic susceptibility of free electrons is calculated, taking into account the wave structure of the electron; it has the same form as the classical formula but the mean free path is replaced by $a/4$ where a is the grating constant of the cubic lattice considered.—**Alexander Goetz**: On the experimental evidence of the mosaic structure of Bi single-crystals. Bismuth single crystals of a definite orientation were grown by a special method and examined microscopically with and without etching. Evidence is obtained that the single crystal contains 'blocks' of a definite size independent of the perfection of the crystal provided the crystal is not plastically deformed. Illustrations of the structure observed are given.—**George H. Shull**: The first two cases of crossing-over between old-gold and bullata factors in the third linkage group of *Œnothera*.—**J. T. Patterson**: Somatic segregation produced by X-rays in *Drosophila melanogaster*. Cultures of eggs and young larvæ of a cross between yellow-white females and eosin-singed males were treated with X-rays and the F_1 females examined. The criterion for somatic segregation was the occurrence of a gray-singed area adjacent to a yellow non-singed area, and this was found in a few cases.—**P. ten Bruggencate**: The radial velocities of globular clusters. There is a linear correlation between the displacements of spectral lines for globular clusters, corrected for solar motion, and galactic latitude, similar to that between line displacement and distance of the spirals. **Wilder D. Bancroft** and **C. E. Barnett**: (1) Solid protein hydrochlorides. The pressure-concentration isotherm for hydrogen chloride gas and charcoal is a smooth curve typical of adsorption; zein gives a similar curve. Hexamethylene tetramine gives a curve with four 'flats'; arachin, casein, edestin, fibrin, and gliadin each gives one or more 'flats'. A 'flat' indicates formation of a compound.—(2) Adsorption of ammonia by proteins. Using the method indicated above, it is shown that ammonia gas combines with tartaric acid (as already known) and with *p*-aminobenzoic acid, but not with aminoacetic acid or the proteins used above.—**Linus Pauling**: The structure of the micas and related minerals. The general formula given for the micas is $KX_nY_4O_{10}(OH, F)_2$, with $2 \leq n \leq 3$, where X and Y are cations of co-ordination number 6 and 4 respectively. The brittle micas have a similar formula in which calcium replaces potassium.—**Hans-Joachim Schumacher** and **Gerhard Sprenger**: The decomposition of nitrogen pentoxide at low pressures. Pressures of 0·2–0·004 mm. mercury were used. There is no marked falling off of the unimolecular constant down to about 0·06 mm. pressure but a decrease below this. Experimental procedure is fully described.—**Elizabeth T. Stafford** and **H. S. Vandiver**: Determination of some properly irregular cyclotomic fields.—**Ernest W. Brown**: On an extension of the Fourier theorem giving rapid methods for calculating the constant part and the coefficient of any periodic term in the disturbing function.—**M. S. Knebelman**: Content-preserving transformations.—**E. T. Bell**: Simplicity with respect to certain quadratic forms.—**Aristotle D. Michal**: (1) The differential geometry of a continuous infinitude of contravariant functional vectors.—(2) Projective functional tensors and other allied functionals.—**G. A. Miller**: Non-Abelian groups admitting more than half inverse correspondencies.—**M. H. Stone**: Linear transformations in Hilbert space. (3) Operational methods and group theory.

Official Publications Received.

BRITISH.

Journal of the Marine Biological Association of the United Kingdom. New Series, Vol. 16, No. 3, May. Pp. 677-1023. (Plymouth.) 12s. 6d. net.

Ministry of Health: Advisory Committee on Water. Report of Technical Sub-Committee on the Assessment of Compensation Water. Pp. 44. (London: H.M. Stationery Office.) 9d. net.

Indian Journal of Physics, Vol. 4, Part 6, and Proceedings of the Indian Association for the Cultivation of Science, Vol. 13, Part 6. Conducted by Sir C. V. Raman. Pp. 449-540. (Calcutta.) 1.8 rupees; 2s.

Third Imperial Entomological Conference, 1930. Programme. Pp. 8. A List of the Entomologists employed in the British Empire. Prepared for the Third Imperial Entomological Conference. Pp. 16. 2s. 6d. A Summary of Data relating to Economic Entomology in the British Empire. Prepared for the Third Imperial Entomological Conference by Dr. S. A. Neave. Pp. 23. 2s. 6d. net. (London: Imperial Bureau of Entomology.)

India. Meteorological Department: Scientific Notes. Vol. 1, No. 7: Normal Monthly Upper Winds over eight Stations in India. Pp. 69-107. 1.12 rupees; 3s. Vol. 1, No. 9: Comparison of Temperatures in Stevenson Screens at Heights of 6 ft., 4 ft., and 2 ft. Note prepared by Dr. K. R. Ramanathan. Pp. 113-121. 7 annas; 9d. Vol. 1, No. 10: Distribution of Temperature in the Lower Stratosphere. By P. R. Krishna Rao. Pp. 123-136. 1 rupee; 1s. 9d. Vol. 2, No. 11: Comparative Observations of Temperature inside White painted, Unpainted and Black painted Stevenson Screens. Note prepared by Barkat Ali. Pp. 11. 6 annas; 8d. (Calcutta: Government of India Central Publication Branch.)

The National Institute of Poultry Husbandry (Harper Adams Agricultural College), Newport, Shropshire. Bulletin No. 3: A Progress Report of Instructional and Experimental Work in Poultry and Rabbit Husbandry. Pp. 80. (Newport.)

The Linen Industry Research Association. Report of the Council, 1929. Pp. 23. (Lambeg, Co. Antrim.)

Empire Cotton Growing Corporation. Report of the Ninth Annual General Meeting. Pp. 16. (London.)

The Journal of the Institution of Electrical Engineers. Edited by P. F. Rowell. Vol. 68, No. 402, June. Pp. 657-800+xxxii. (London: E. and F. N. Spon, Ltd.) 10s. 6d.

The National Institute of Industrial Psychology. Report 4: The Measurement of Manual Dexterities. By F. M. Earle, assisted by Dr. F. Gaw and other Members of the Institute's Staff. Pp. 88. (London.) 5s.

The Eton College Natural History Society. First Annual Report, 1929-30. Pp. 42+3 plates. (Windsor.)

University of Bristol: Department of Agriculture and Horticulture. Bulletin No. 4: Mole Destruction Experiments. By A. W. Ling, C. A. MacEachern and E. C. Read. Pp. 15. (Bristol.)

Navy—Hydrographer's Report. Report on Admiralty Surveys for the Year 1929 by the Hydrographer of the Navy. Pp. v-x. (London: Admiralty.)

FOREIGN.

Spisy vydávané Přírodovědeckou Fakultou, Masarykovy University (Publications de la Faculté des Sciences de l'Université Masaryk). Čís. 115: i. Příspěvek ke studiu adičních sloučenin organických zásad se solemi zinečnatými (Contribution à l'étude des composés l'addition formée par des bases organiques avec des sels de zinc), napsali J. V. Dubský a A. Rabas; ii. Příspěvek ke studiu tvorby soli glykokolu (Contribution à l'étude de la faculté de la glycocolle de former des sels), napsali J. V. Dubský a A. Rabas; iii. Příspěvek ke studiu zásaditých solí, se zvláštním zřetelem k ol-solím měďnatým (Contribution à la connaissance des sels basiques, particulièrement par rapport aux sels "ol" du cuivre), napsali J. V. Dubský a E. Tesařík. Pp. 29. Čís. 116: Musci insulare Rossicae prope Vladivostok. Ad Bryophytorum Orientis Extremi cognitionem additamentum. Scripsit Josef Podpěra. Pp. 40. Čís. 117: Reflexion des ondes acoustiques sur un plan. Par B. Hostinský et J. Kaucký. Pp. 13. Čís. 118: Měření doby kyvu gravitačních vah (Mesure de la période du gravimètre). Napsal Josef Zahradníček. Pp. 15. Čís. 119: Hydrolysa solí berylinatých a hlinitých odvozených od silných kyselin (Hydrolysis of beryllium and aluminium salts derived from strong acids). Napsal Václav Čupr. Pp. 24. Čís. 120: Buzení krátkých elektromagnetických vln dvoumřížkovými lampami (The emission of short electromagnetic waves by two grid valves). Napsal Josef Sahánek. Pp. 17. Čís. 121: Propriétés projectives du contact, II. Par Edouard Čech. Pp. 21. Čís. 122: A Study of Ideational Behavior of a Garden-Warbler, *Sylvia borin borin* (Bodd.). By Vladimír Teyrovský. Pp. 36. (Brno: A. Píša.)

Sborník Vysoké Školy Zemědělské v Brně, ČSR (Bulletin de l'École supérieure d'Agronomie, Brno, RCS). Sign.C16: Škůdce cukrovky *Bothynoderes punctiventris* Germ. a jeho přirození nepřátelé (The Sugar-Beet Pest, *Bothynoderes punctiventris* Germ. and its Natural enemies). Napsal Dr. Jan Rozsypal. Pp. 92. Sign. C17: Příspěvek k poznání příčin neplodnosti kozlů (A Contribution to the Knowledge of Causes of the Sterility in the Bucks). Napsal Dr. Jan Podhradský. Pp. 32. Sign. D14: Hydrobiologická studia rybníků Lednických. 1. Výzkum heloplanktonu a jeho poměrů quantitativních. Podávají Prof. Em. Bayer a Al. Bajkov. Pp. 165. Sign. D15: Význam polykání peří u *Podiceps cristatis* (L.) a obsah jeho žaludku (La déglutition des plumes et le contenu de l'estomac chez le *Podiceps cristatus* (L.)). Napsal Dr. Josef Jirsík. Pp. 23. (Brno: A. Píša.)

Scientific Papers of the Institute of Physical and Chemical Research. No. 241: On the Combination Series of Helium. By Yoshio Ishida and Tadashi Tamura. Pp. 115-134+plates 14-18. 45 sen. No. 242: Über die Bestimmung der Teilchengrösse pulverförmiger Substanzen. Von Kōichi Kasai. Pp. 135-183. 75 sen. Nos. 243-244: Volumenahalizo de Magneziaj Saloj, II., de Tutomu Maeda kaj Ryûzô Syôzi; La Solvebleco de Kalcio Sulfata en Akvosolvaĵoj de Alkoholoj, de Takemaro Yamamoto. Pp. 185-206. 40 sen. (Tōkyō: Iwanami Shoten.)

California Academy of Sciences. Constitution and By-Laws, Trustees, Officers, Museum Staff and Members, May 29, 1930. Eighth edition. Pp. 87. (San Francisco.)

CATALOGUES.

High Tension Cable Testing and Fault Locating: a Description of the High-Tension Direct Pressure Test for Cables and Overhead Lines. Pp. 28. (London: Watson and Sons (Electro-Medical), Ltd.)

Newspapers, Magazines, Periodicals and Journals of Learned Societies. (Catalogue 526.) Pp. 40. (London: Francis Edwards, Ltd.)

The Photexray X-ray Tube. Pp. 24. (London: Cuthbert Andrews.)

"Liverpool" Paper Insulated Low Tension Cables. Pp. 16. (Liverpool: The Liverpool Electric Cable Co., Ltd.)

Diary of Societies.

FRIDAY, JULY 4.

GEOLOGISTS' ASSOCIATION (at University College), at 7.30.—Dr. C. T. Trechmann: The Relation of the Permian and Trias in North-East England.—J. J. Hartley: The Volcanic and other Igneous Rocks of Great and Little Langdale, Westmorland.—*Paper to be taken as read*:—P. Jessop: The Agates and Cherts of Derbyshire with a Brief Account of the History of the Lower Carboniferous Limestone of the Peak District.

ASSOCIATION OF ECONOMIC BIOLOGISTS (at National Institute for Research in Dairying, Shinfield, near Reading).

MONDAY, JULY 7.

ROYAL INSTITUTION OF GREAT BRITAIN, at 5.—General Meeting.

TUESDAY, JULY 8.

INSTITUTE OF TRANSPORT (at Glasgow).—E. J. H. Lemon: Railway Amalgamation and its Effect on the Workshops.—Sir G. C. Buchanan: The Economics of Port Development and Administration.—W. J. Thomson: Long-Distance Omnibus Services—their Place in the National Scheme of Transport. (*Continued on July 9 to 12.*)

WEDNESDAY, JULY 9.

INSTITUTION OF MINING ENGINEERS (at Birmingham). (*Continued on July 10 and 11.*)

CONFERENCE.

JULY 8 AND 9.

SOCIETY FOR EXPERIMENTAL BIOLOGY (in Department of Zoology, Birmingham University).

Tuesday, July 8, 2.15 to 3.45.—V. B. Wigglesworth and E. K. Sikes: The Hatching of Insects and the Appearance of Air in the Trachea System.

Prof. H. Munro Fox: Spectroscopic Analyses of Tissues.

P. D. F. Murray: The Differentiation of the Somites and Limb-Bud of the Chick.

5 to 6.—D. L. Gunn: Water Metabolism of the Cockroach.

R. Snow: Some New Aspects of Correlative Inhibition.

Wednesday, July 9, 10 A.M. to 1.—Prof. W. Stiles: The Toxic Action of Alcohols and other Substances on Plant Tissues.

W. N. Howarth: Polymeric Forms among Carbohydrates.

E. L. Hirst: High Polymerides in the Carbohydrate Group.

Prof. J. H. Priestley: The Plant Cell Wall.

W. T. Astbury: The Structure of Wool-fibres by X-ray Analysis.

2.15 to 3.45.—L. C. Beadle: Effects of Low Salinities on Water Content and Respiration of Marine Animals.

C. F. A. Pantin: Adaptation of *Gunda ulvae* to Changes in Salinity.

F. T. K. Pentelow: The Fauna of the River Lark.

4.30 to 5.30.—J. Gray and S. B. Setna: The Growth of Fish Scales.

M. A. Tazelaar: Further Work on the Effects of a Temperature Gradient on the Early Development of the Frog.

CONGRESS.

JULY 10 TO 12.

OXFORD OPHTHALMOLOGICAL CONGRESS (at Oxford).

Dr. H. M. Traquair, Sir Farquhar Buzzard, Bart., Prof. J. A. Gunn: Symposium on Toxic Amblyopia.

Sir Oliver Lodge: Modern Theories on the Nature of Light.

Dr. H. Friedenwald: Pathological Changes in the Retinal Blood Vessels and their Significance (Doyne Memorial Lecture).

Prof. A. Schüller: Recent Developments in Radiology Associated with Ophthalmology.

Prof. J. Gonin: Detachment of the Retina and its Treatment.

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